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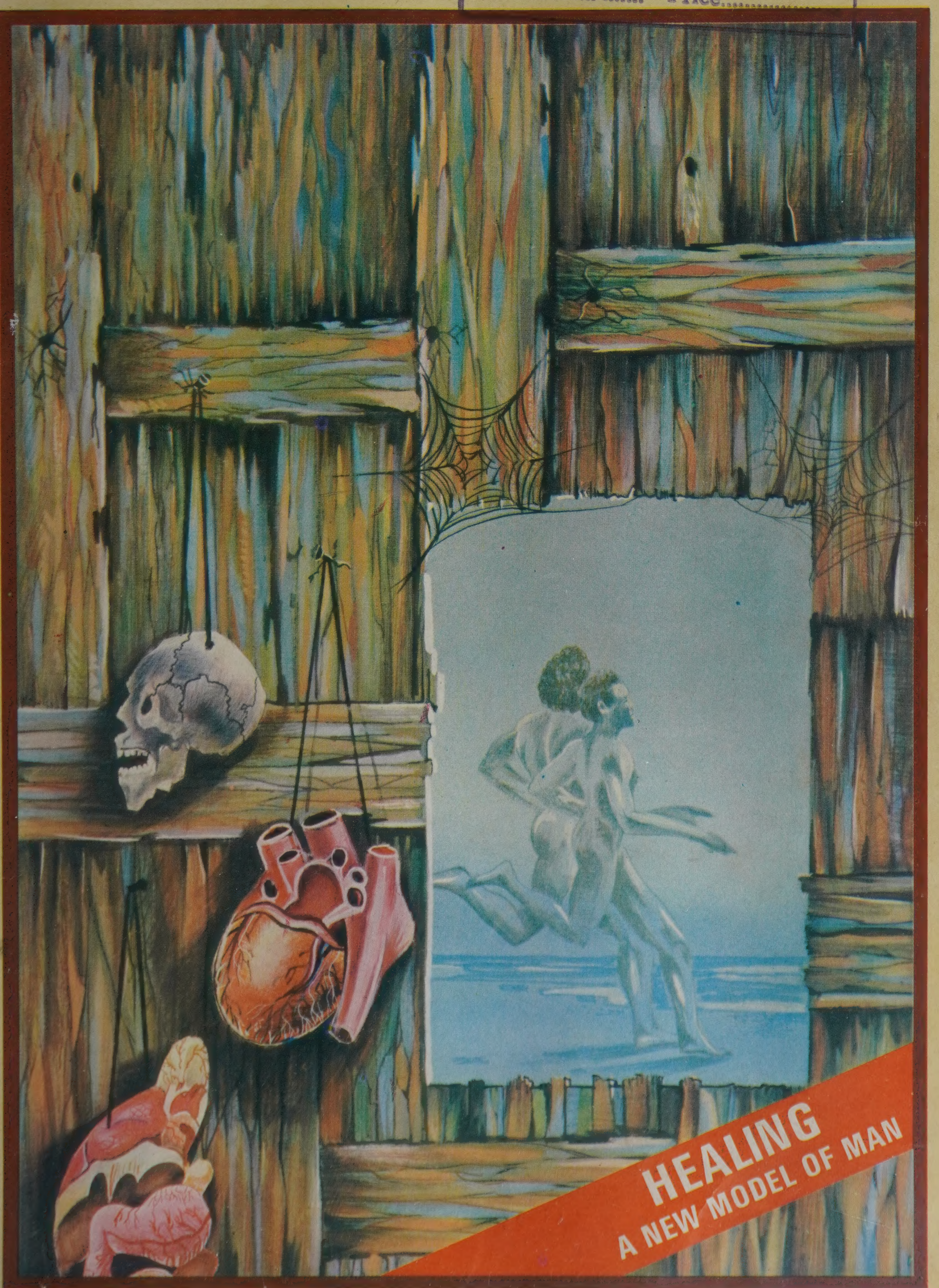

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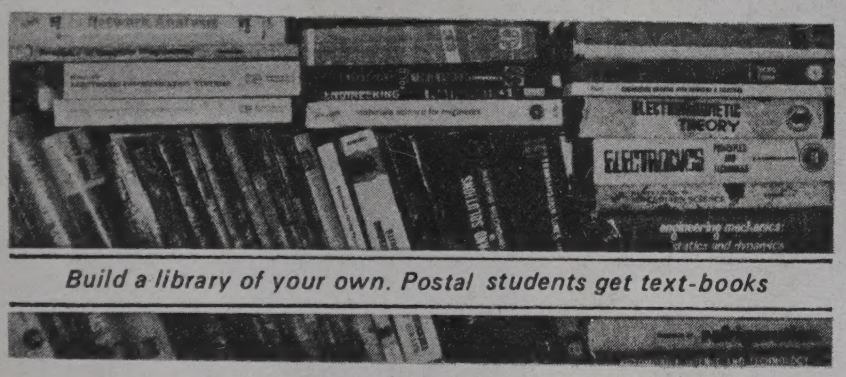

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SURENDR JHA

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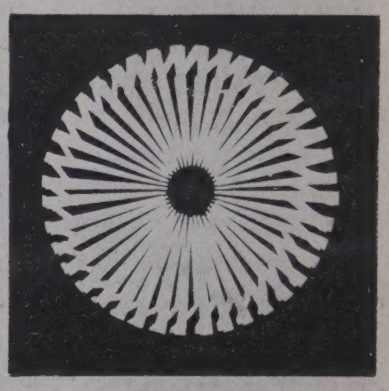

LETTERS

Wash-n-wear finishing

Textile finishing is not a gimmick (" Cotton fabrics and the finishing gimmicks ", April 1977). In fact, it is an exact science. Koratrom Co of the USA and Tootal Broadhurst and Lee of England have laid down fabric specifications, depending on end-uses, and they specifically insist that in no case a customer should be cheated. Only when strength characteristics mentioned in their manual are maintained in the fabrics do they permit their resin finish labelling.

Wash and wear is an important improvement in the overall concept of resin finishing. Durable-press (DP) is a step forward, with higher crease recovery angles and no need to iron the DP garments after washing.

DP fabrics have the highest amount of resin added on. As the resin add-on is increased, wash and wear properties improve. However, simultaneously, degradation (or loss in strength retention) sets in. The more the resin added, such as for DP level, the higher will be the strength loss — to the tune of 30 to 55 per cent.

The level of resin finishing done depends upon the initial quality of the fabric. Only fabrics with highest strengths are given a high resin add-on; or, in other words, only those fabrics that can stand such high resin add-on and still maintain performance characteristics are given DP treatments. Weaker fabrics get shrink-resistant or anticrease finishes. Still weaker fabrics are never given any treatment.

The success of DP garments depends on: (i) finishing mills; (ii) garment manufacturers; and (iii) the care exercised during home washings. In India, the DP concept has failed. All the finishes are more or less " wash-n-wear " or with still lower levels of anticrease. Anyway, they are better than untreated fabrics so far as ironing is concerned; they need only mild ironing or a touch of ironing for a sharp wear after washing.

D. V. PARIKH
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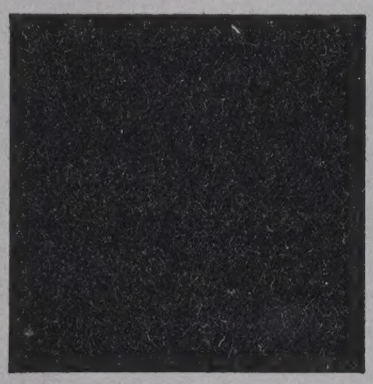
A. B. Nair Road
Juhu, Bombay-400 054

Black holes?



First detailed colour photograph of a black hole. Note features at upper left and centre, in good agreement with current theoretical predictions.

The " first detailed colour photograph " of a black hole (May 1977, p. 17) was just that — a black hole! Was there a mistake?

JAYANTH KURIYAN
Hyderabad

No mistake. *Mercury* had printed it as a joke. Since black holes trap even light, they must remain invisible!—Ed.

Bathroom singing

Mr. Chander Shekhar is right when he says that males sing more frequently in the bathroom than females (" Letters ", May 1977). But why do they sing at all? That one feels more relaxed when water cools the nerves is not true, because then it should be the same in both the sexes. The reason is more psychological and physiological. There is an echo of our voice in the closed environment of the bathroom which pleases our ears, and we sing more and more. It is also known that female voices have a higher frequency compared to males'; they do not produce such a good echo as male voices.

UMA KANT SHARMA
P.O. Kasimpur, Aligarh-202 127

One reason why men sing more frequently than females may be that men always pour water over their heads while bathing, whereas women usually do not wet their heads. Thus, the relaxing effect is more pronounced in males.

RAJIV SHARMA
E1/15, Model Town, Delhi-110 009

Cockroaches and homeopathy

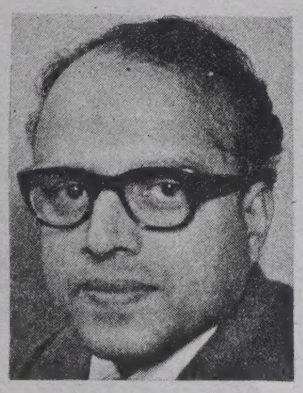
This has reference to the news item " Cockroaches and asthma " (May 1977, p. 9). The homeopathic ***Materia medica*** is based on symptoms produced in healthy males and females by administering drugs in material doses. The same drug in dilutions ranging from 10^{-3} to 10^{-200} or more is given for a disease which has symptoms similar to that produced by the drug. It is considered that the drug thus diluted provokes a reaction in the body which destroys the disease-producing noxious agent. This is similar to the preventive therapy in modern medicine. Diseases like diphtheria, whooping cough, tetanus, typhoid, cholera, polio, smallpox, etc are eradicated on this principle.

There are some diseases which are cured or relieved by homeopathic drugs which have been discovered accidentally. ***Blatta orientalis,*** or the cockroach, is one such. It has been used for many decades as a homeopathic drug to cure or relieve asthma. According to the homeopathic principle, the cockroach should cause asthma, and this is now proved to be true.

M. S. KIRLOSKAR
Sadhankeri, Dharwar-580 008

AWARDS & APPOINTMENTS

Swaminathan elected to US academy



Dr. M. S. Swaminathan, Director-General, Indian Council of Agricultural Research (ICAR), has been elected Foreign Associate of the National Academy of Sciences of the United States. Dr. Swaminathan is the third Indian scientist to be elected Foreign Associate of the US National Academy of Sciences. The other two were: Dr. V. Ramalingaswami (1973), Director of the All-India Institute of Medical Sciences, New Delhi, and Dr. D. Lal (1975), Director of the Physical Research Laboratory, Ahmedabad. Dr. Swaminathan has been chosen for his outstanding contributions to applied genetics and biology.

Nehru Fellowship

Dr. S. Ramaseshan, head of the materials division section of the National Aeronautical Laboratory, Bangalore, has been awarded the Nehru Fellowship. He will study " the life and work of Sir C. V. Raman ". Dr. Ramaseshan's main fields of work are optics, anomalous scattering of X-rays and neutrons, and low-temperature crystallography. He is a former student of the late Sir C. V. Raman.

Industrial design

The National Institute of Design, Ahmedabad, has won the first award of the International Council of Societies of Industrial Design, Eindhoven, Netherlands.

Dr. Joshi honoured

Dr. A. B. Joshi, Vice-chancellor of the Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, and former Director of the Indian Agricultural Research Institute, has been appointed a member of the International Board for Plant Genetic Resource (IBPGR), Rome, and of the Technical Advisory Committee (TAC) of the Consultative Group of International Agricultural Research, Rome.

Dr. B. C. Roy award

Dr. T. Manickam, an ENT specialist and president of the Karnataka Medical Council, has been given the Dr. B. C. Roy award in the category for " encouraging and development of specialities in different branches of medicine." Dr. Manickam had founded the Venkateshwara ENT Institute at the Victoria Hospital in Bangalore. He had also helped to set up modern ENT services in several district hospitals. The other winner, in the category for teaching, is Dr. G. S. Sainani, professor and head of the Department of Medicine, B. J. Medical College, Pune (see SCIENCE TODAY, May 1977, p. 61).

TV IN INDIA: EDUCATION OR ENTERTAINMENT?

It appears that television has come to stay in India. Now that it is soon going to be in the hands of a new policy-making body, an autonomous corporation, it is worthwhile to stimulate discussions at this stage to review past achievements and to visualise possible goals for the future. The arguments here deal with regular telecasts and exclude consideration of the SITE project which was a separate experiment, special in many ways.

The introduction of television in India was marked by the promise that it would play a significant role in national development, and this promise continues to be renewed from time to time. It is time to ask, if this promise has been fulfilled in any major way? Has television been effectively used as an instrument for education? Has adequate attention been paid to the areas which are important to us, for instance in:

- Providing significant assistance to school teaching;
- Providing forums for education outside traditional institutions, providing for life-long education;
- Enriching the learning environment of young children;
- Educating the underprivileged, especially in the rural areas, about their rights, and the various government schemes meant for their benefit, which often fail to reach them?

Though TV transmitters are located in urban centres, their range does cover large rural populations. They are, however, too poor to profit from it in the absence of community sets.

We should also ask if TV has made a serious effort to evaluate modern educational techniques being developed elsewhere that would be relevant to India? Has it encouraged, stimulated or sponsored the development of such techniques indigenously?

A specific example of a major development in this area is the British Open University which, using a 300-man production team in the BBC, has employed television to make post-school education inexpensive, widely accessible, available to the working adult and relevant to the realities of life.

The questions we have raised here relate to serious or 'hard' attempts in education. Any TV programme, say, an interview with an economist here or a political commentator there, can be claimed to be educational. News, or even an essentially frivolous word-game, can be presented in this light. We do not contest the argument that most TV programmes have some incidental educational value. But we would like to preclude attempts to confuse such programmes with hard educational programmes which have been professionally designed and evaluated for their educational effectiveness. That such educational programmes can attract and hold large audiences has been adequately established.

TV shapes its own audience

One of the arguments put forth by TV producers is that they have to give the viewers what they want; otherwise, they just turn off.

This is, in a sense, true. But the argument can easily be turned around, especially in our situation with TV in its early stages of expansion. What is telecast in the early years will determine the nature of the viewing population we gather and their expectation in the years to come. If we go in mainly for entertainment and provide an inadequate educational component, entertainment will almost certainly grow to be the dominant feature and TV will get out of hand. We are afraid that this trend has set in already, and if it continues, there will be no incentive for any one to increase school ownership and other community ownership of TV sets. TV will become essentially the entertainer of the upper middle class, despite all claims about its role in education. We are concerned with the fact that schools equipped with TV in India today constitute a negligible percentage of the total, and with the fact that the effort going into production of well-designed educational TV programmes is very limited. It is a pity that we have to depend on imported science programmes for quality and effectiveness, largely because of the scarcity of impressive Indian programmes.

At present, the body that produces educational programmes and telecasts them is not responsible for ensuring their effective utilisation. Individuals and individual systems of schools may or may not use them, and there is no clear minimum expectation to be fulfilled. Admittedly, TV receivers are very expensive for schools to purchase, but a good part of the expense is due to taxes which can surely be waived in some way or the other, for sets owned by schools or the community. There is a fear about maintenance of large numbers of receivers, though the Indian experience clearly indicates that the problem is managerial rather than technical. There is also some concern that expenditure on educational TV can be easily diverted to benefit the privileged urban viewers, who already have access to reasonably good education rather than the underprivileged going to the poorer schools or not going to school at all.

What is needed now is an unambiguous commitment to the objective of making TV play a major role in education. This can be ensured only by taking adequate steps at the time of setting up the autonomous corporation. This corporation should be given proper direction by its written constitution and mandate, to bring TV to bear on India's educational development. If we do not attempt this at this stage we will surely miss the bus.

In this last quarter of the 20th century, a nation like India faces many special problems. It also has opportunities that others did not have at a comparable state of development, educational TV being a good example. In the final analysis, it is the political will which is going to decide if planning for television takes the right direction.

B. M. UDGAONKAR
S. RAMANI

B. M. Udgaonkar is a professor at the Tata Institute of Fundamental Research, Bombay, and S. Ramani is a research scientist in the same Institute. Professor Udgaonkar is also a member of the University Grants Commission; Dr. Ramani is active in the field of Educational Technology.

What TV does elsewhere: an example

The University of Mid America (UMA) in Lincoln, Nebraska, USA, is a TV University. People who enrol for its courses get credit for work towards a degree. But their TV programmes are also watched by thousands of others who may not have enrolled.

UMA realises this and serves both target groups. To provide written material (including tests to be self-administered) to the non-enrolled people, UMA persuaded a local newspaper (readership 300,000) to carry a series of articles to accompany its courses. The first series telecast was on "Accounting", and it was shown to be highly popular on the basis of a readership survey. Nine per cent of the readers followed the articles, a record beaten only by the comic strips, sports news and the Ann Landers (personal questions) column.

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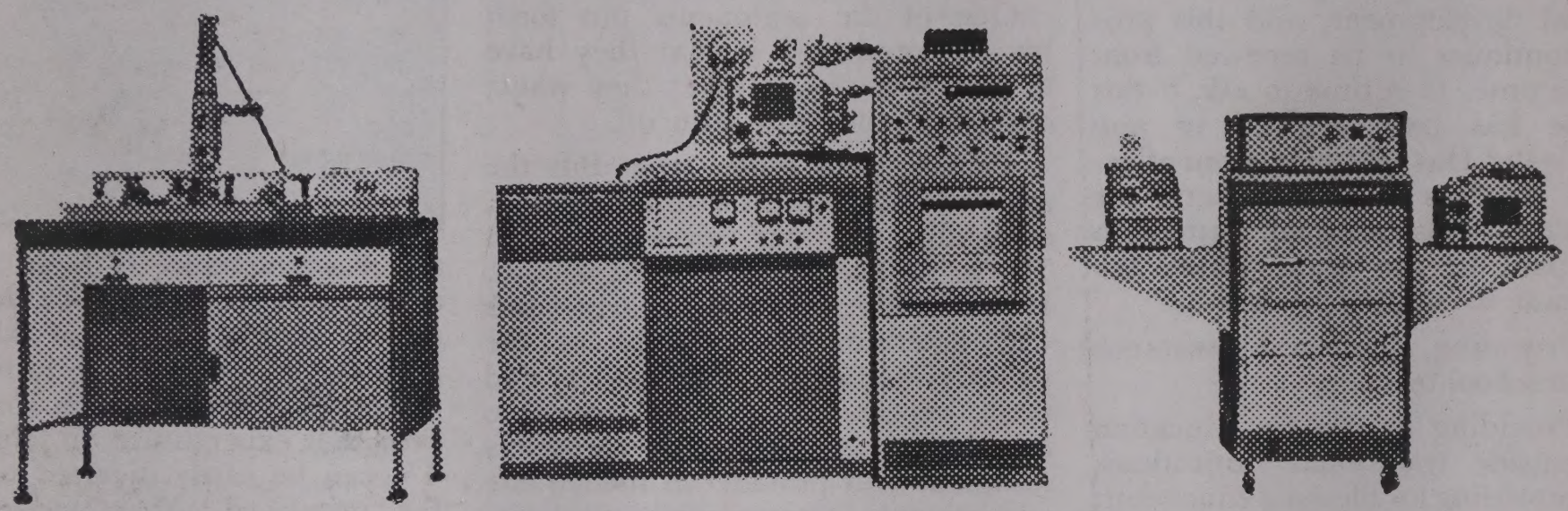

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BIG CITIES GOOD, SMALL CITIES BAD

When somebody inveighs against the glass and concrete jungles of today, which are commonly believed to affect the quality of life, there is something you can stop his mouth with: it is the follow-up study of the famous Mid-town Manhattan Study of 1954. The follow-up suggests that contrary to accepted views, small towns and rural areas don't necessarily have an edge over big cities in providing a congenial environment for humans. Apparently, man is resilient enough to adapt himself to urban chaos after a generation or two.

Many were shocked by the findings of Leo Srole of Columbia University (USA) in the 1954 study that 23 per cent of New York's East-Side residents were in need of psychiatric treatment, but they later accepted it as true of most cities. In the follow-up study, Srole reports that the mental health of Manhattan residents has improved greatly, compared to small city and town dwellers. In the 1974 study, Manhattan subjects answered almost the same questions on symptoms they had answered 20 years ago. The answers from persons 40 to 60 years old were compared with those of respondents in the same age-range in 1954; the samples in both the studies are representative of both rich and poor persons in predominantly white areas.

During the two decades, persons with 'impaired' mental capacity in the 40 to 49 and 50 to 59 age-groups dropped from 16 to 8·4 per cent and 21·7 to 10·3 per cent, respectively. To explain this, Srole says that respondents in their fifties in the first survey were brought up by parents who grew up in the late 1800s, and their environmental, occupational and educational settings were quite different from those of the 1974 respondents.

Srole combined his study with data from other surveys and concludes, in a presentation at the American Psychiatric Association last May in Toronto, that persons who lived in rural areas and in cities of fewer than 50,000 population had higher symptom scores than people who lived in cities with larger populations.

WHY BABY LANGURS GET KILLED

Probably the most startling finding in recent years by those who study primates is that those we regard as our closest relatives, among all orders of mammals, are a blood-thirsty lot. About a dozen species, representing every group of primates, both in the New World and the Old World, are now known in which infants are killed whenever a male takes over a group; this is apart from cases of adults fighting each other to the death. Males attack infants when they come into possession of females accompanied by offspring sired by another male. Such killings have also been observed among caged animals.

Dian Fossey in a remarkable decade-long study of mountain gorillas in Central Africa has recorded several instances of fully mature males ("silverbacks") killing infants belonging to primiparous mothers; in the best documented case, the mother subsequently copulated with the male who had killed her infant.

In India, such behaviour among langurs has been noted by several observers. Dr. Sarah Blaffer Hrdy of the Department of Anthropology, Harvard University (USA), who studied five troops of langurs around Mount Abu, observed infant mortality whenever a troop was taken over by a new male. The females, who had lost their infants, gave birth again within 27 months.

One explanation for such behaviour is that infanticide helps check population in crowded areas. However, Dr. Hrdy, writing in *The American Scientist* (January-February 1977), suggests that the behaviour is not pathological since it was directed at infants only. In fact, it is a result of what Darwin called 'sexual selection', that is, competition between members of one sex (typically males) resulting in fewer offspring for the less successful males. In the case of the langurs, the usurping male increases his own reproductive success at the expense of the former leader of the troop (presumably the father of the infant killed), the mother and the infant.

HOW TO DESIGN AN INSECT ZOO

A lot of fuss is being made about damage that may be done by lethal strains of bacteria that could be let loose by uncontrolled experiments in recombinant DNA. The critics fail to emphasise that even existing plants and animals can create havoc if transplanted to a new environment. The case of the prickly pear is well-known. The fire-ant, which administers a burning sting, probably introduced from Brazil or Argentina, has now become an unwelcome resident in nine southern states of the USA.

Naturally, when the Smithsonian Institution (USA) wanted to set up an insect zoo for educational purposes, the Animal and Plant Health Inspection Service of the US Department of Agriculture thought it should take a hand. It laid down that the males and females of risky insects like leaf-eating moths and plant-lice should not be imported in the same year

but in alternate years, to preclude mating, reports *Bioscience* (January 1977). The zoo is designed to guarantee containment of the bugs. All cages are made of plexiglass with several layers of metal and rayon screening on top, treated with an antistick paint so that insects don't stick to the screen and crawl off when it is opened. The insect hatchery has heavy double doors separating it from the rest of the museum, and seals on all windows, doors and drains.

THE BRAIN'S CHEMICALS COULD CAUSE ALCOHOLISM

Is alcoholism a disease? Medicine hasn't proved this as yet. Meanwhile, workers at Purdue University (USA), suggest that it could have an activator in the chemicals of the brain.

Robert D. Myers and Christine L. Melchior of the University's Laboratory of Neuropsychology found that rats which previously shunned alcohol could be made to drink by injecting tetrahydropapaveroline (THP), a compound derived from alcohol, into their brains. Before injection with THP, the rats drank mostly water and only traces of alcohol. After injection, the rats increased alcohol consumption as much as 20-fold, compared to the control group which received injections of brain fluid. Even six months after the THP infusions were stopped, the rats continued to drink large amounts of alcohol. The results indicate the possibility that some cellular defect in the alcoholics' brain may cause abnormal formation of

MAKES PURSE-SNATCHING DIFFICULT

The plastic alarm box goes inside a pocketbook or purse and the cord is fastened to your finger or wrist. When the cord is torn from the box, as it would be if a thief grabbed the purse, the buzzer in the alarm box comes on. Most thieves' reaction would be to drop the purse and run. Powered by a battery, the device costs $3 (Rs. 24).

THP at specific, sensitive sites. The only hope, the researchers say in a report in *Science* (29 April 1977), for a recovered alcoholic to avoid relapse is total abstinence.

MEASURING SCIENTISTS' OUTPUT

What is the measure of a scientist's productivity? The number of publications to his credit? And if so, what kind of publications?

The number of papers published is by itself no criterion. Since there are more than 50,000 scientific and technical journals in the world, a paper can ultimately get published if the author is determined, says S. M. Lawani in an article in *Bioscience* (January 1977). Nor is the journal in which they are published a reliable index. Even prestigious journals sometimes publish substandard papers. The rate of rejection too, varies greatly. *Physical Review* published about 80 per cent of submitted papers, and *Bioscience* (in 1975) about 59 per cent.

However, in general, quantity and quality are correlated, and scientists who achieve distinction are industrious. Of 41 American scientists who had got elected to the National Academy of Sciences, 11 had 300 or more publications each; the median number was 145.

Of late, citation analysis has been used as a rating of a paper's quality. Most people agree that the number of times an author or paper has been cited in scientific literature is a valid measure of the quality of the paper or the author's contribution. References and footnotes cited in a number of journals are now published in the *Sciences Citation Index* and the *Social Sciences Citation Index*. The average number of citations for Nobel Prize winners in physics between 1955 and 1965 was 58, compared with an average of 5·5 citations for other scientists. Interestingly, prospective laureates were more highly cited than actual laureates.

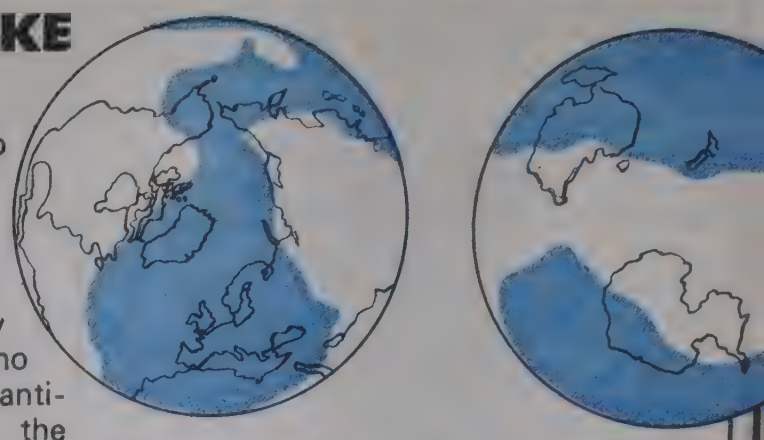
However, there are some drawbacks to the method of citation analysis. It is the practice to cite only the first author (others being covered by the term *"et alia"*) ; since most papers are multi-author papers, this may result in undervaluation of persons who are not first authors.

Other studies suggest that outstanding contributions are cited many times, while

50 per cent of all published papers are not cited at all. A paper of average quality may attract a large number of citations if it deals with a controversial subject or one in the research frontier.

OUR EARTH IS LIKE A TENNIS BALL

Like the two strips that make up the covering of a tennis ball, the Earth, too, is divided into two regions — one "high" strip and another "low" strip, according to D. I. Gough of the University of Alberta (Canada), who discovered this "remarkable anti-symmetery" after transferring the contours of a Mercator map of the Smithsonian Standard Earth II geoid to a globe. The high strip runs across the north pole, with one lobe covering the western Pacific and most of Australia and another covering parts of the south Atlantic and south Indian Oceans (with a subsidiary extension over the South American Andes). The 'low' strip, which slices through Antarctica, has one lobe over the northern part of the Indian Ocean (including India and Asia) and the other lobe covers North America, the eastern Pacific and Brazil.



The coloured area represents the "high strip" as calculated by D. I. Gough

According to Gough, the 'high' and 'low' might correspond to the convection movements in the whole mantle, though the exact relationship is yet uncertain. If, however, the 'highs' could be related with the downward currents, Gough postulates, it could probably explain why the Pacific plate moves faster than the North Atlantic Ridge.

VIDEO DISC PLAYERS ARE COMING!

Sometime this year, video disc players are expected to be put on the US market by two world-wide organisations. You

slip in a disc and see a recorded TV programme you would like to see again. The discs and the systems, however, are vastly different from the familiar 33⅓ and 45 rpm discs and current audio systems.

One of the models plays a rigid 12 in (30 cm) diameter disc with 30 minutes playing time on both sides. The disc spins at 45 rpm. TV signals are encoded as minute depressions at the bottom of each groove. The discs have a vinyl base, topped with thin layers of metal, an insulating plastic and an oil lubricant that reduces stylus wear. The disc and the stylus together form an electrical circuit. As the slots spin past the stylus, tiny abrupt changes in the circuit capacitance occur. These changes de-tune an oscillator circuit to produce the TV signals.

Another model makes use of a radically different concept. Only one side of the aluminium disc is programmed. A low-power laser focussed to a one-micron spot strikes the bottom side of the disc and falls on a spiral track that consists of oblong bumps of varying lengths, with flat areas in between; the distance between the bumps varies with the encoded picture information. The flat areas between the bumps reflect part of the laser light through the optics to a light sensitive diode that detects the TV signal. The discs should last indefinitely, since there is no wear; the helium-neon laser 'stylus' lasts a minimum of 10,000 hours.

If the brisk sales of video-cassettes are any indication, the video-disc players should be great hits.

TURNED INTO GOLD

It looks as if the dream of the alchemists — to turn base metals into gold — is coming true. But, in this case the material used is not a base metal but one costlier than gold — uranium.

The transmutation took place when experimenters of the Society for Heavy Ion Research in Germany were looking for a nucleus of one of the artificial elements of atomic number greater than uranium, that is, element 105. They bombarded a uranium target with uranium ions accelerated to 1·8 billion electron volts energy in the heavy ion accelerator called Unilac, located near Darmstadt. This energy is not enough to accomplish a complete fusion of the accelerated uranium nuclei with those in the target, but a certain exchange of protons and neutrons does occur. The result is that, one of the uranium nuclei becomes gold, and the other, element 105.

Whether the transmutation is worthwhile on a commercial scale would depend on the current prices of uranium and gold. In the last analysis, a nuclear scientist might have better uses for his uranium!

SLOWING DOWN SENILITY

Standard therapies involving drugs that dilate the blood vessels, and tranquillisers, yield little return in cases of senile

dementia. M. H. Knisely of the Medical University of South Carolina (USA) had noted that constriction of vessels and arteries in ageing can cause red blood cells to adhere or aggregate and impair blood flow. He also pointed out that diabetes and alcoholism, among other conditions, can cause blood sludging. Arthur C. Walsh, a clinical assistant professor at the University of Pittsburgh (USA) and a psychiatric consultant at the Veterans Administration Hospital, Pittsburgh, who was aware of this work has now come to the conclusion that red-cell aggregation is the major cause of senility. Theories of arteriosclerosis attribute it to degeneration of the cells themselves or the onset of some virus that slows the flow of blood to the brain. Walsh also hypothesised that since severe emotional stress can cause stroke and heart attack, it is a contributor to vessel constriction and therefore blood sludging. He found that 22 out of 24 patients improved when given the anti-coagulant bishydroxycoumarin (" Dicumarel "). " Coumadin " was also effective. Psychiatry also helped the patients. Apparently what the drugs do is to reverse, or at least slow down, the senility, by breaking up the sludging and rejuvenating such cells.

VITAMIN E AND AGEING

The finding in 1972 that vitamin E could extend the lives of rodents by about 30 per cent has prompted gerontologists to see whether it could help humans. They suspect that vitamin E does the trick by protecting cells from the excess oxidation produced by free radicals (highly reactive chemicals in the cells), but they are not able to specify how exactly.

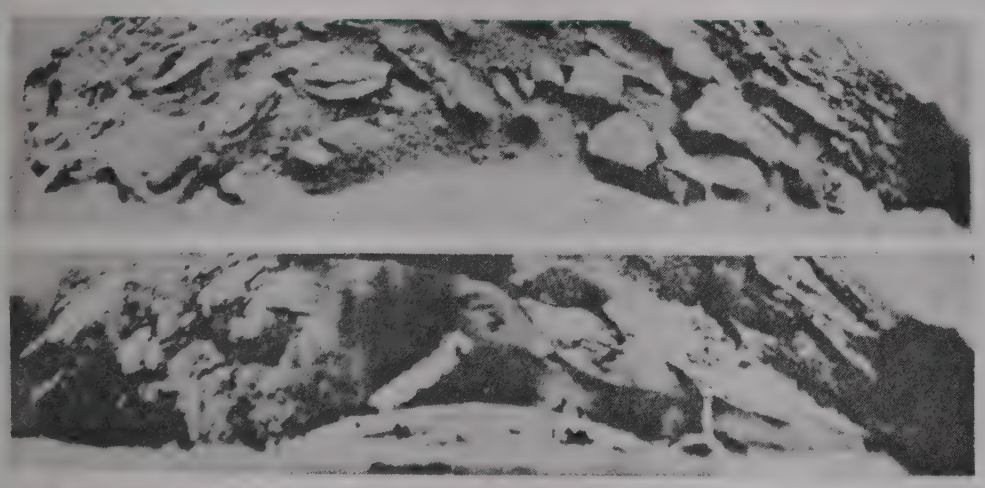
Experiments conducted by Lester Packer of the University of California, Berkeley (USA), and James R. Smith of the Veterans Administration Hospital, Martinez, California (USA), seem to confirm the anti-ageing effect of the vitamin. The vitamin appeared to double the usual life-span of human lung cells in the test-tube, compared with control cultures of lung cells. But, not being able to repeat these results — an essential condition in scientific research — they concluded that the calf serum (the fluid portion of blood) used in the first experiment for culturing cells was in some way different. They were not able to identify this factor in the serum, which might have interacted with vitamin E, because each lot of serum that scientists buy from biological companies is non-identical.

NEW TUNNELLING TECHNIQUE

Building a tunnel in soft ground is always a problem. If you have spent your holidays on the seashore with a bucket and spade, you will know basically what it means. The famous Thames tunnel built between 1825 and 1843 was the first tunnel to be driven for public traffic beneath a river. A UK firm, with the support of the National Research and Development Corporation of UK, has developed a new tunnelling process which aroused much interest within the civil engineering profession and at the international symposium 'Tunnelling 1976', held in London.

Tunnels often become necessary for underground railways and sewers in cities and often they have to be dug in unstable ground. One type of machine used extensively consists of an open-ended drum of steel having a rotating cutting head at one end and a number of hydraulic jacks around the inner periphery at the other end. The head is rotated to cut the ground at the front of the drum, while the jacks at the other end are pushed backwards against the end of the latest ring of tunnel-lining installed, thus pushing the drum forward into the ground being cut. The new machine developed with NRDC assistance has, in addition, a bulkhead at the tunnel face which contains a pressurised slurry of bentonite, a sort of clay which when mixed with water becomes a thixotropic jelly (becoming increasingly viscous with passage of time if left undisturbed).

This bentonite slurry is of advantage when ground water is encountered while tunnelling; otherwise, expensive compressed-air machinery has to be used to keep out the water.



Panoramic photo by Venera 9 (top) and Venera 10 (bottom)

BEHIND THE VEIL OF VENUS . . .

Soviet scientists are puzzled by two features in the pictures of the Venusian surface sent to them by the probes Venera 9 and 10 which landed on Venus in October 1975. Venera 9 photographs show boulders with sharp edges — even sharp points — suggesting that they were produced by the breaking of originally hard rocks. In the absence of liquid water to cause erosion, it is hard to explain the Venera 9 photographs, unless they can be put down to Venusian quakes. The Venera 10 photographs of the landing site show outcrops of hard material with pitted surface and rounded edges. These photographs are even more puzzling because the weathering cannot be caused by the gentle winds and the inert atmosphere of carbon dioxide — unless the atmosphere contains hitherto undetected active chemicals (possibly contributed by volcanic eruptions). The report is made in *Science* (20 May 1977) by C. P. Florensky and his associates at the V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow.

The data from the landers indicates very low wind velocity (1 m/sec) as well as low atmospheric water vapour. Nor can meteoritic impact cause much weathering, because the atmosphere is so dense that no meteorite smaller than 30 m, if iron, or 60 m, if stone, can penetrate it.

. . . A GIANT VOLCANO

However, radar pictures obtained by Richard M. Goldstein of Jet Propulsion Laboratory, Pasadena, USA, suggest the existence of a giant volcano, even bigger than Olympus Mon, the giant Martian volcano, which itself is five times the height of Mount Everest.

Named Beta, earlier researchers had seen the near-featureless bright spot on the northern hemisphere of Venus for nearly a decade without suspecting its true dimensions or nature. That this spot could be a volcano is implied by the way it polarises the radar beam, suggesting the rough surface of a volcanic region. Its width, about 700 km across, with a central depression or caldera about 90 km wide, dwarfs the 550 km width and 60 km wide caldera of Olympus Mon! By comparison, the entire volcanic island of Hawaii, even measured from the seabed, is puny, attaining about 120 km width at the maximum, with a 3 km wide main caldera. In altitude, however, Olympus Mon may still beat Beta, because Venusian gravity, which is two or three times the Martian gravity, and higher temperatures, would have produced plastic rocks, perhaps incapable of rising to great heights.

There are other features in the two-dimensional radar reflectance images of Venus — trough-like depressions and possibly a curved mountain range — which suggest largescale activity in the planet's crust in the past.

The supervolcano Beta (shown by arrow) on full-disc radar image of Venus

PHYSICAL RESEARCH LABORATORY

AHMEDABAD-380 009

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SHRI HARI OM ASHRAM PRERIT DR. VIKRAM SARABHAI RESEARCH AWARDS FOR 1977

The Physical Research Laboratory makes **four awards** every year, called Shri Hari Om Ashram Prerit Dr. Vikram Sarabhai Research Awards, from funds kindly donated by Pujya Shri Mota of Hari Om Ashram of Nadiad, Gujarat. These awards are to be made to Indian Scientists, who are not above 45 years of age (on 1st January of the year of the award), for original work in the following fields:

(1) Electronics and Telecommunications;
(2) Planetary and Space Science;
(3) Atmospheric Physics and Hydrology;
(4) Systems Analysis and Management.

Although the over-all work of the candidates would be taken into account, the work done by the candidate in India would be given primary consideration.

The candidate should have to his credit, at least one or more of the following achievements:

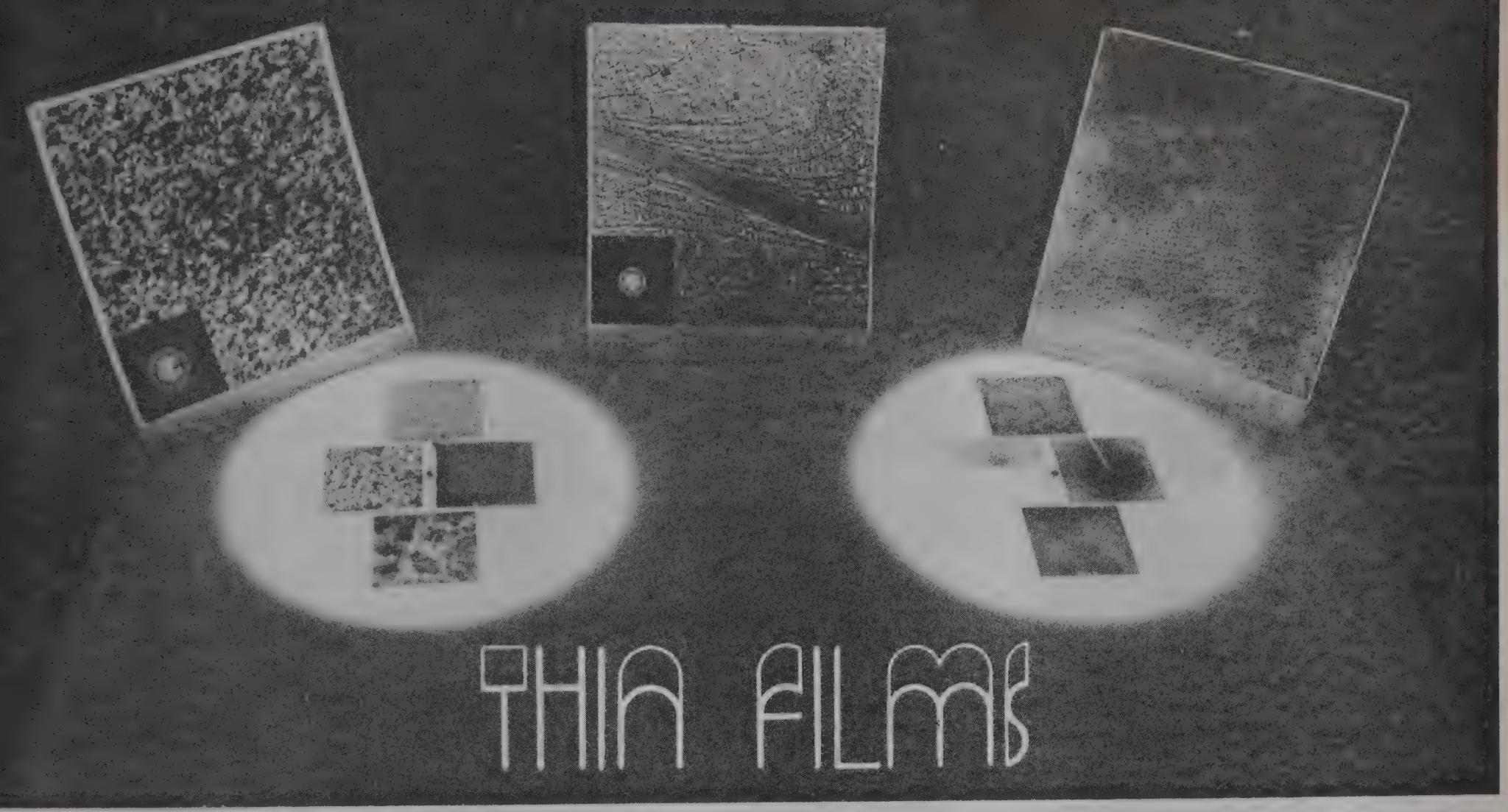
(a) Significant achievement in scientific research,
(b) Important and successful adaptation on new technology,
(c) Planning, development and implementation of systems in the context of science and technology.

The selections for the year 1977 will be completed by December 1977 and the awards presented on 12th August 1978.

Nominations are invited from responsible scientists. The last date for receiving nominations is **15th September 1977.**

Sponsors are requested to send a two-page note summarising the contributions and achievements of the sponsored candidate together with his/her bio-data, to Professor D. Lal, Director, Physical Research Laboratory, Navrangpura, Ahmedabad-380 009. Only nominations made for the year of the award would be considered.

More detailed information will be asked for by the Selection Committee, if considered necessary.



Electron micrographs and electron diffraction patterns of different materials show the arrangement of clusters of atoms in the early stage of growth of a material. At extreme right is shown the molecular chains of PVC. The chains are lined up in a systematic manner, made possible by a new technology developed at the Thin Film Laboratory of IIT, Delhi. This article outlines some aspects of thin film technology

K. L. CHOPRA

Miniaturised integrated optical circuits using thin film devices, akin to integrated electronic circuits, may soon bring about a revolution in communications technology. Thin film solar cells may enable many nations to tap the unlimited solar energy when the fossil fuel reserves run out. Thin film superconductors may carry electricity for hundreds of kilometres without any transmission losses. This is, of course, for the future. But the technology of thin films is already proving useful in such articles of daily use as artificial jewellery, anodised household appliances, Thermos flasks, magnetic tapes, goggles, coated optics of a camera or a microscope, Xerox machines, miniaturised thin-film resistors and capacitors and vidicon or electroluminescent panel/display devices. It is also finding application in basic sciences.

Indeed, the tremendous advances made by the science and technology of thin solid films in the last two decades have led to the creation of many new and full-fledged scientific disciplines. They include microelectronics, micromagnetics, thin film optics, integrated optics, amorphous (glassy) materials, thin film superconductivity, and surface science. The creation and understanding of the structures of thin films have been assisted by, and this, in turn, have been largely responsible for, the developments in such fields as ultrahigh vacuum technology, electron (transmission as well as scanning) microscopy, low/medium/high energy electron diffraction, and a variety of surface analytical techniques like Auger spectroscopy, secondary ion mass spectroscopy and electron spectroscopy for chemical analysis.

What is a thin film and what makes it so uniquely important in the study and application of solid state physics? A material having one of its dimensions about one micron (10^{-4} cm or 10,000 Å) or less is the geometrical description of a thin film. A commonly used gold or silver foil of a few thousand Angstrom thickness as obtained in our country by a beating process is *not* a thin film. Nor are those sprayed/varnished/painted/coated surfaces thin films, even though their thickness may be of less than a micron. (In fact, films so obtained are also of considerable technological interest in such areas as microelectronics and protection and passivation of surfaces. These films, generally thicker than one micron, belong to a new discipline called Thick Film Technology.)

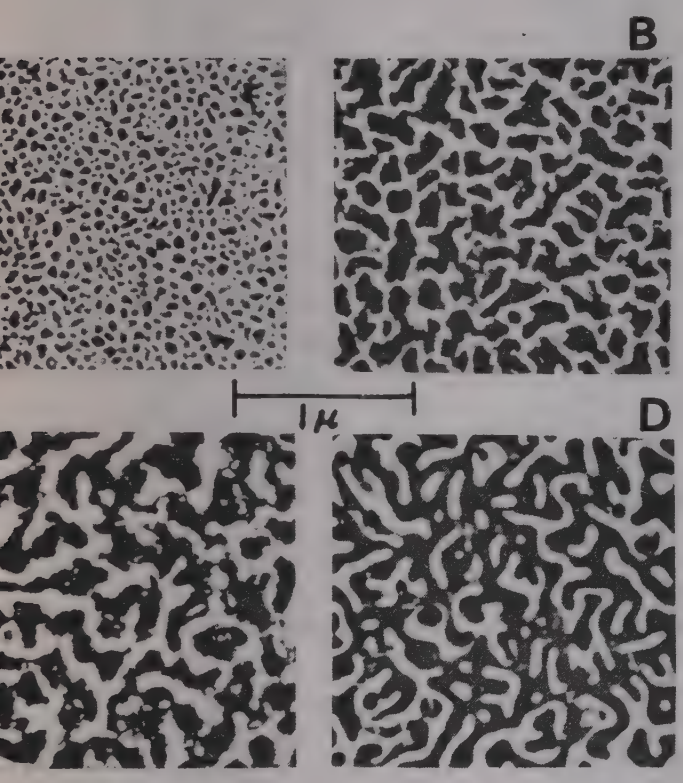
What, really, characterises a thin film is the process by which it is obtained. The growth process is of fundamental importance to the science and technology of thin films, since it largely determines the film's novel structural behaviour and properties. A thin film may then be scientifically defined as a thin two-dimensional material — born of an atom (molecule)-by-atom (molecule) condensation process. The condensation is generally achieved from the vapour phase of a material.

It may be worthwhile now to examine the process of condensation of a beam of vaporised atoms/molecules intercepted by a solid surface called substrate. The vapour atoms interact with the surface atoms of the substrate via *Van der Waals forces* and get physically adsorbed. The adsorbed atoms (called "adatom") soon lose the velocity component normal to the surface, but retain the velocity component in the plane of the substrate. The motion they execute is a random walk. The adatoms encounter others of the same species and bond with them to form a cluster. The volume cohesive forces due to bonding would increase with the increasing number of adatoms in the cluster, but, at the same time, the disruptive forces due to the presence of dangling or dissatisfied bonds at the free surface of the cluster would increase. There, thus, exists a critical size at and beyond which the cohesive forces are decisive in bringing about the chemical adsorption of the stable cluster. This process of nucleation yields three-dimensional randomly distributed islands which grow further by the addition of new atoms from the

vapour phase as well as by surface diffusion.

The occurrence of such three-dimensional islands in ultra thin films of metals, insulators and semiconductors has been well-established by electron microscopy. The growing islands coalesce into one another by surface and volume diffusion forming a network which fills gradually to form a continuous film (see Fig. 2). The solid state process of coalescence as seen with an electron microscope is very rapid in the case of metals; it appears as a liquid-like coalescence process. In summary, the thin film is born of a nucleation process and grows by a process of coalescence (sintering) between microscopic clusters. The coalescence phenomena have a profound effect on the structure and properties of the resultant film since recrystallisation, grain growth, orientation changes, incorporation and removal of defects, etc occur as a consequence of coalescence.

Fig. 2 A sequence (a) to (d) of electron micrographs of Ag films of 100, 105, 110, and 115 Å average thickness, respectively, evaporated onto NaCl at 100°C, demonstrating the rapidity of the coalescence process leading to a network structure



A film thus represents the *ab initio* birth of a material. But, what is perhaps the most significant aspect of the birth process is that it (and hence the corresponding microstructural details) can be modified drastically by changing the conditions of deposition like the chemical nature and temperature of the substrate, rate and angle of deposition, energy and species of the vapour atoms, nature and degree of vacuum, etc. These parameters affect the mobility of the adatoms, and the size, distribution, and coalescence characteristics of the islands.

Changing the conditions of deposition

What are the major advantages of changing the conditions of deposition? By controlling the temperature of deposition it is possible to nearly immobilise the adatoms on the substrate. Consequently, they have little chance to grow together in a harmonious and ordered manner (which is so characteristic of a lot of matter found in nature). The result is an amorphous or glassy state (devoid of long range order). At the other extreme, the adatoms can be given high mobility leading to the formation of matter in a granular form with a regular arrangement of atoms (polycrystalline). If the surface happens to be a single crystal (with regular and periodic arrangement of atoms over the whole surface), the periodic forces of cohesion induce an oriented growth (called epitaxy or "arrangement on") in the film with a geometrical arrangement of atoms which is well-defined and correlated (but not necessarily the same) with that of the substrate atoms. Most significantly, a large number of elemental materials, and most of their alloys and compounds can be obtained in amorphous, polycrystalline or epitaxial (often, though wrongly, called single crystal) forms. Excellent examples of interest are: W, Mo, Ta, Fe, Cu-Ag, Ge, Si, Ge-Te, and Ga-As. Fig. 3 illustrates this point in the case of sputtered molybdenum films. What is noteworthy is that the single crystal films can be obtained at deposition temperatures well below the melting points of the materials and also the normal temperatures required for the growth of bulk crystals. Thus, single crystal films of gold, silver and copper can be obtained at or below room temperature, in contrast to about a thousand degrees required for the formation of bulk single crystals of these metals.

In the early stages of growth, the films consist of islands and empty channels and are thus porous on a microscopic scale. Even on coalescence of the islands, the misfit of geometrical boundaries leads to the freezing-in of a host of defects such as vacancies, vacancy clusters, dislocations and stacking faults. The porosity as well as the concentration of the various defects can, however, be controlled and modified over a very wide range. One can prepare films such that the effective area for gaseous adsorption and catalytic reactions is hundreds of times larger than the simple surface geometrical area. Further, it is not uncommon to freeze-in several atomic per cent vacancies and $\sim 10^{14}$ lines/cm^2 of dislocations in films deposited at room temperature. The concentration of induced defects can be several orders of magnitude larger than that frozen in a bulk crystal by such harsh treatments as cold working and irradiation by energetic particles. An electron micrograph (Fig. 4) of a silver film illustrates the variety and high concentration of defects.

A crystal has a unique and characteristic geometrical arrangement (lattice) of atoms; the stable arrangement is determined by minimum energy consideration. Since interatomic forces in small clusters can now be significantly modified with surface, strain, electrostatic and magnetostatic (in case of magnetic materials) energy, the energy balance may favour the formation of new and unusual arrangement of atoms in small clusters having a few to tens of atoms. This metastable arrangement, once produced, could, in principle, propagate. The phenomenon has in-

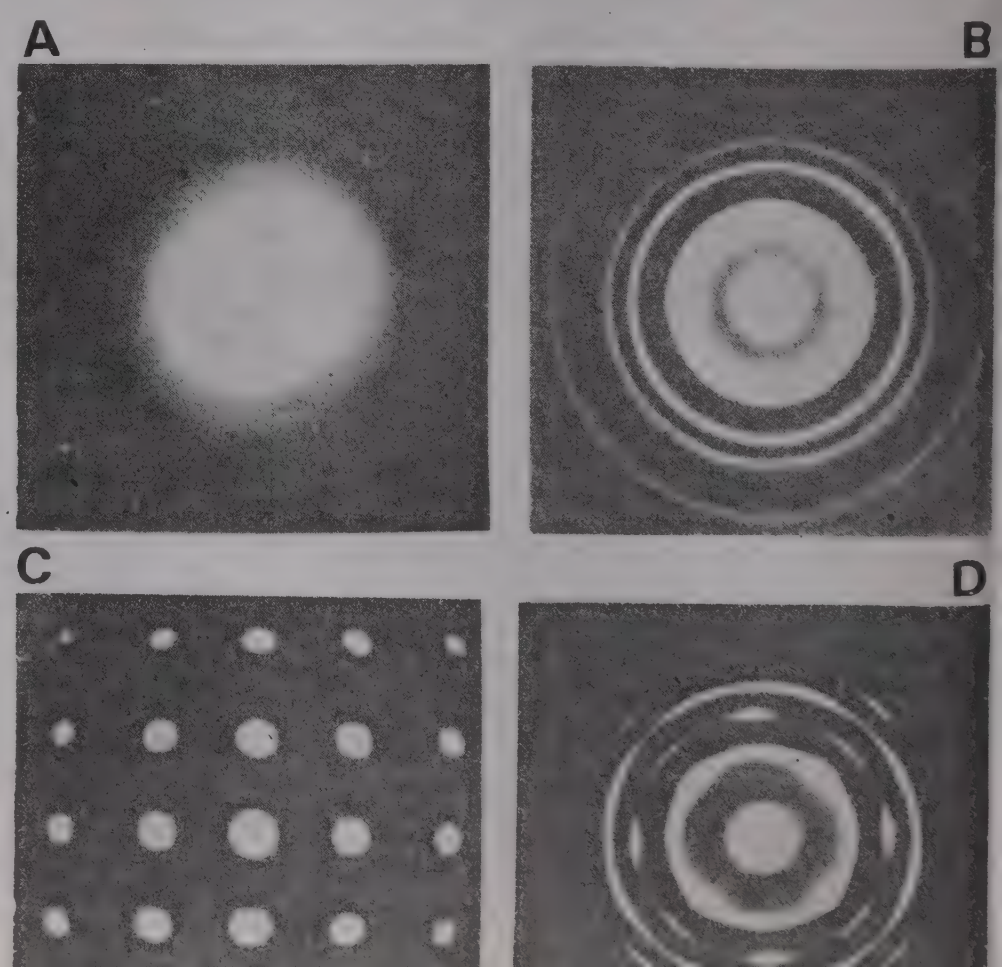


Fig. 3 Electron-diffraction patterns of 500 Å-thick Mo films ion-beam-sputtered onto NaCl at (a) 23°C, amorphous; (b) 250°C, fcc metastable; (c) 450°C, fcc metastable single crystal; (d) fcc annealed to 675°C in vacuum, fcc + bcc Mo

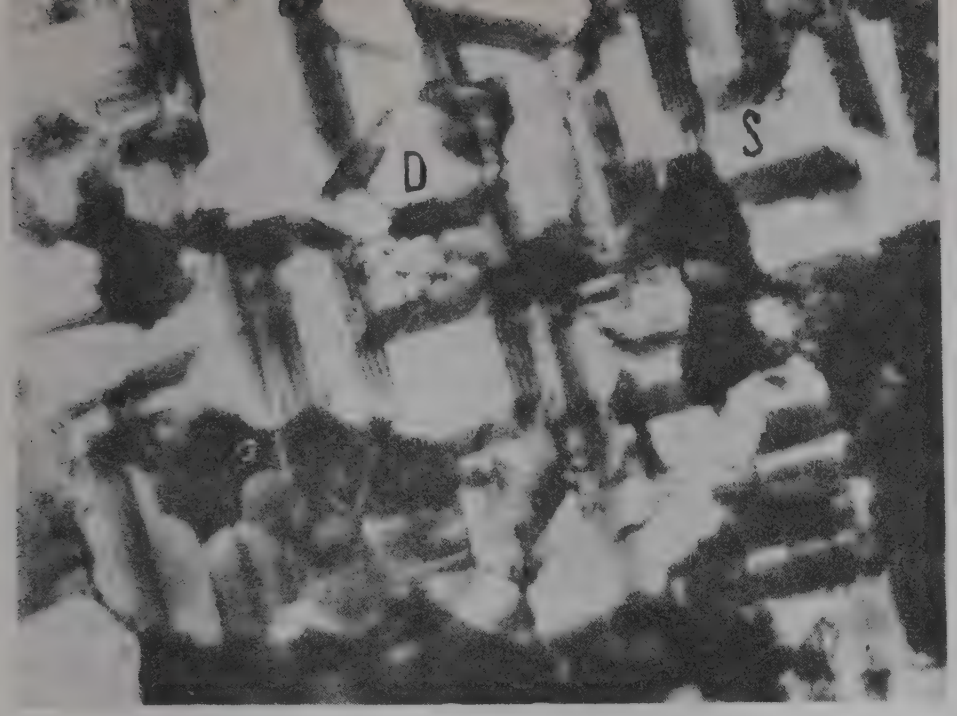


Fig. 4 A typical transmission electron micrograph of 1,000 Å-thick epitaxial Ag film evaporated onto cleaved NaCl at 200°C, showing stacking fault (S) fringe arrays, dislocations (D), and other defects

deed been amply demonstrated in a large number of metals, alloys and compounds. Based on his extensive work, the author has formulated rules for the existence/occurrence of these new and unusual metastable phases of materials. As an example, semiconducting sulphides, selenides, tellurides, arsenides and phosphides of a number of metals may be stabilised in either the cubic or hexagonal phase; some properties of the two phases are quite different. For instance, only hexagonal cadmium sulphide is useful for surface wave devices, whereas cubic phases of the same material find application in other devices.

The solubility of one material in another is governed by a number of physical rules. Thus, two materials can be dissolved into each other to form alloys or compounds only for specific ranges of composition. The atom-by-atom condensation process of thin films can relax the solubility criteria so that literally any material A can be made to mix with any material B in some composition range. If A and B are soluble in bulk, their solubility range can be extended, quite often to the entire composition. A number of seemingly unthinkable materials like ZnS-MgF_2, $Pb_x Hg_{1-x}S$, metallopolymers, Cu-Ag, etc can thus be formed. In special cases, where the material A tends to become amorphous, and the atoms of material B have a high mobility, their mixing results in an island structure of B studded with clusters of A. This ceramic-metal microscopic composite is called "Cermet" and is of considerable technical interest in the manufacture of thin-film resistors because of the possibility of obtaining a very wide range of resistivities and temperature coefficient of resistivity (TCR) in these materials.

Besides the microstructure, the surface topology of a film can also be modified in numerous ways. Surfaces of atomic smoothness at one extreme, and very rough and columnar (like the lunar surface) at the other can be obtained in the same material by changing the deposition conditions (see Fig. 5). Thus, films of the same material with a whole range of surface, electronic and optical properties can be created.

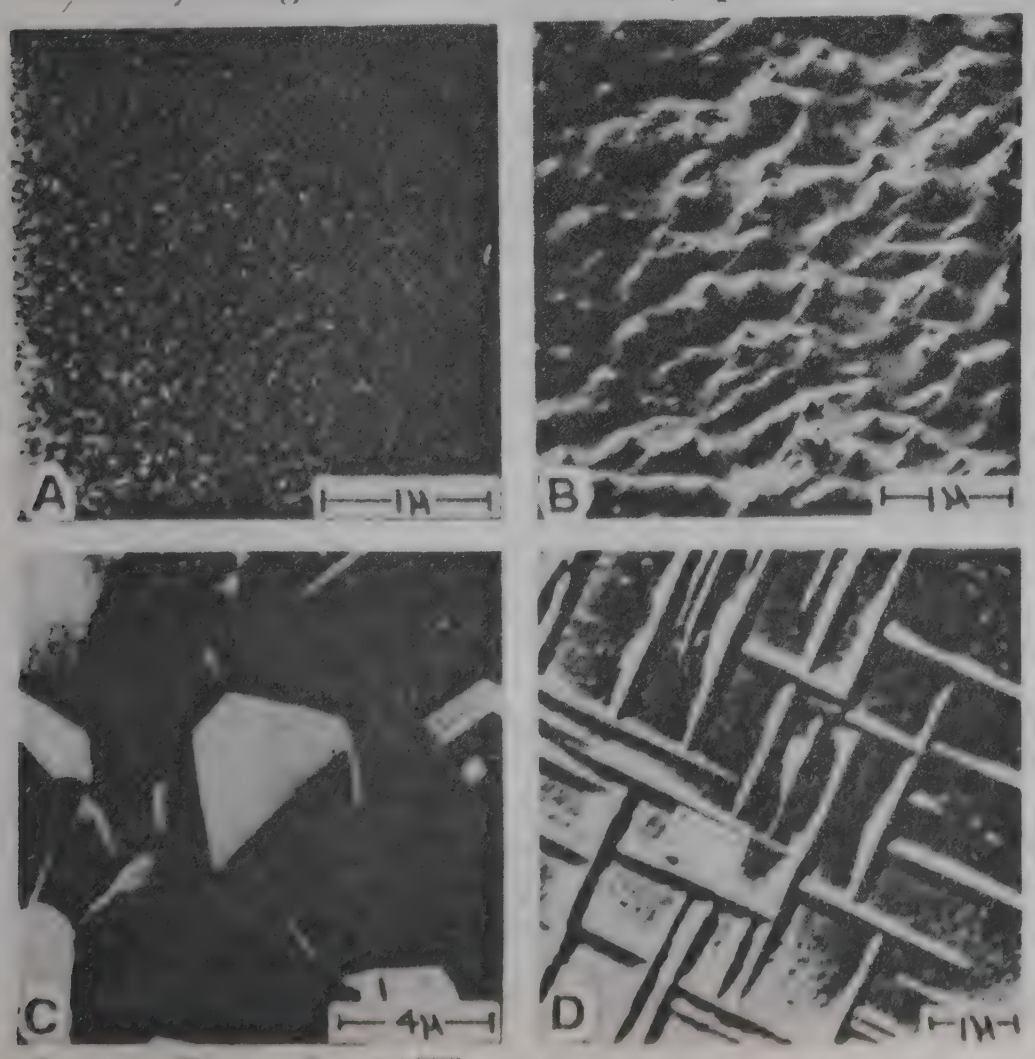
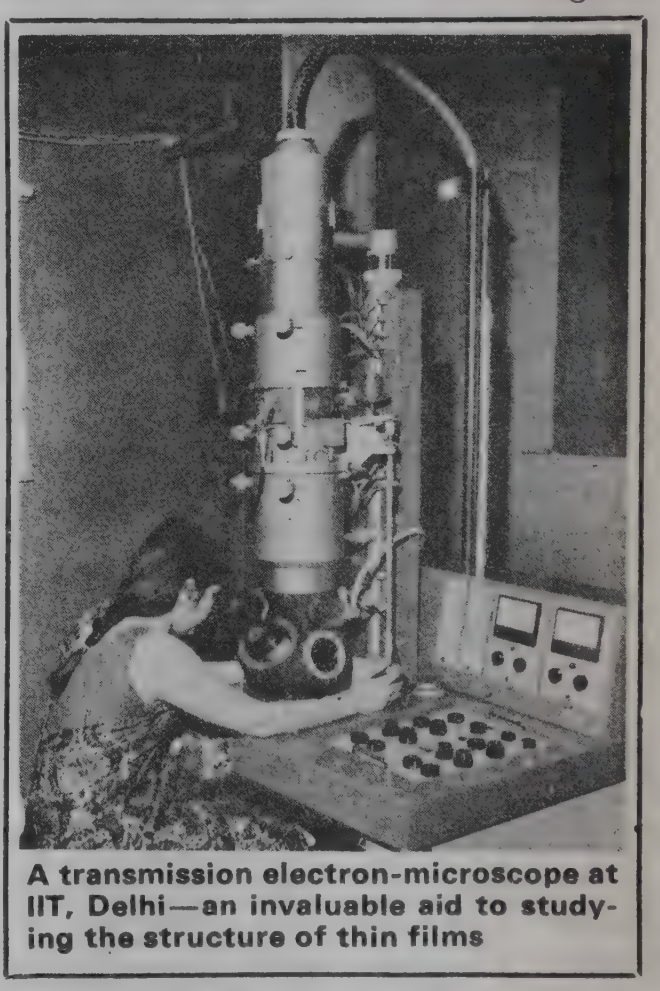


Fig. 5 Electron micrographs of a variety of surfaces of different films: (a) atomically smooth, 1,000 Å sputtered Au film on NaCl; (b) a rough Ag film evaporated on mica at 300°C, roughness caused by a deposition rate exceeding 3,000 Å/min; (c) a faceted growth with platelet crystals in a 3-μ —thick Bi_2Te_3 films sputtered on glass at 400°C; and (d) a rod-like crystallite growth of polyoxymethylene film on (KCl [110] direction shown by an arrow) from nitrobenzene solution held at 120°C

The innumerable unnatural and unusual structures and microstructures that can be obtained in thin films of a material are beyond the imagination of a solid state physicist or a materials scientist working with bulk materials. This alone should justify our insistence on defining a thin film not merely in terms of its dimensions but also in terms of its mode of creation.

The unusual structures of films represent thermodynamically non-equilibrium states. But, these structures have a long-term stability under controlled environmental conditions and also provide the scientist with unusual physical phenomena of enormous academic and technological interest. It would not be an exaggeration to state that the future technological revolutions are critically dependent on new materials with high strength, high elasticity, high superconducting transition temperature, high dielectric breakdown, high permeability, high optical transmission, etc. However unrealistic it may seem now, thin films of some materials have already provided the materials scientist considerable encouragement in the search of such exotic and uncommon materials.



A transmission electron-microscope at IIT, Delhi—an invaluable aid to studying the structure of thin films

Applications

Let us now discuss some major applications of thin-film materials. The creation of a large concentration of structural defects increases the mechanical (tensile) strength of a thin film. Films of metals having hundreds of times greater strength than that of the bulk have been obtained. Larger internal stresses ($\sim 10^9$ to 10^{10} dynes/cm^2), comparable to the yield strength of most

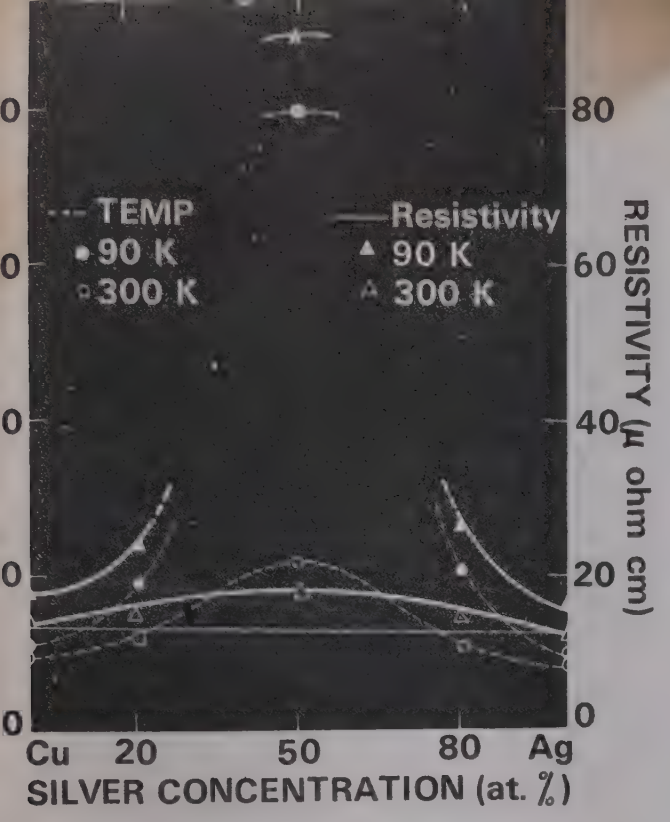


Fig. 6 Thermopower and resistivity of as-deposited/unannealed (at 90 K) and annealed (at 300 K) $Cu_{1-x}Ag_x$ films of various compositions

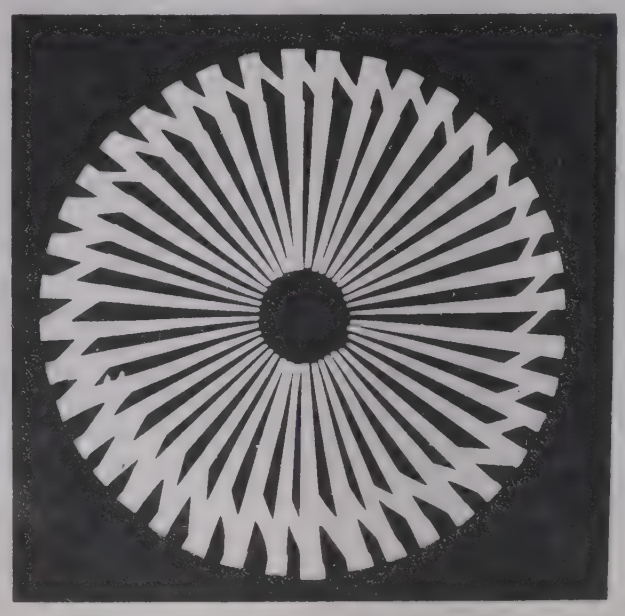
bulk metals, are known to develop in thin films during their growth. These have profound effects on the electrical, magnetic, superconducting and semiconducting properties of films. On destruction of the long range order, amorphous films also assume significantly different electronic, magnetic and optical properties. Fig. 6 illustrates how the resistivity and thermoelectric power of Cu-Ag films of various compositions increase by factors of about 100 and 25, respectively, in the amorphous state. It should be noted that copper and silver do not mix with each other in bulk but can form metastable crystalline as well as amorphous alloys in thin films. The large value of the thermoelectric power in disordered metal alloy and semiconductor films is exploited in the construction of sensitive and fast bolometers or thermopiles. The thermopile shown in Fig. 7 consists of 40 Cu-constantan thermocouples developed in our laboratory and can measure a millionth of a degree temperature difference between the hot and cold ends. Individual thermocouples can record temperature changes occurring in less than 10^{-8} sec. A whole array of fast thermocouples is being used for commercial and military applications in advanced countries as a night vision device for producing infrared images of objects in the dark and for thermography of objects.

The high resistivity and the strong photoconductivity of selenium films form the backbone of the xerographic process which has caused a revolution in information dissemination. Some amorphous semi-conducting alloys/compounds of selenium with sulphur or arsenic have the useful property that, on irradiation with suitable light, the image of an object can be imprinted on a film of the material in the form of changed optical transparency. This change can, of course, be " read " and then " erased " by a thermal bleaching process. We thus have an optical memory system for storage and retrieval of information. Holographic memories and gratings have, in fact, been created on a commercial basis this way. A new development of considerable impact is that the modifications in the transparency of some amorphous films on irradiation can be " developed " chemically so as to produce either a " negative " or a " positive " image of the object. The physical and chemical basis of image formation is presently being investigated in our laboratory. Technologically, it may constitute a new, simple and economical process for high resolution photolithography (for applications in integrated circuit technology) and photography. The fact that the image is produced in a thin film of a thousand Angstrom thickness and of grains with atomic dimensions ensures an image resolution of ~100 Å or less. The reproduction of a high resolution mask in a 500 Å thick amorphous germanium-based film deposited in vacuum or glass is shown in Fig. 8.

Single crystal and polycrystalline ferromagnetic films have been prepared under a wide variety of conditions. The magnetic properties of such films are largely determined by the magnitudes of the magnetic anisotropy present in the film. Polycrystalline films of metal iron alloys (81 per cent Ni, 19 per cent Fe, sometimes known as 'permalloy') have the unique magnetic property that the direction of magnetisation is confined to the plane of the film if the demagnetisation field is larger than the anisotropy field. In such a case, the magnetisation can be rotated and reversed at very high speeds (under application of magnetic fields of a few Oersteds) — a phenomenon which is the basis of the exploitation of Ni-Fe films for magnetic memory devices in a computer. If, on the other hand, the anisotropy field is much larger than the demagnetisation field, as is the case in the crystalline as well as amorphous alloy films of Gd-Co, Gd-Fe, Gd-Mo, Co-P, Tb-Ni, Gd-Co-Au, etc, the film can be magnetised in the form of cylindrical domains (called magnetic bubbles), a few microns in diameter, perpendicular to the plane of the film. Packed to a density of 10^6 to 10^7 per cm^2, the bubbles can be moved fast at speeds up to 10,000 cm/sec by the application of small magnetic fields. One can store, transfer or retrieve information in such bubbles. The high density of bubbles coupled with a high speed of access (10^{-8} to 10^{-9} sec) make magnetic bubble devices very attractive for computer memory applications (see SCIENCE TODAY, March 1973, p. 29). Information may also be magnetically written in crystalline or amorphous films of Mn-Bi and Gd-Co and read out magneto-optically by utilising the large effect of Faraday rotation (the rotation of the plane of vibration of polarised light on traversing an isotropic transparent medium placed in a magnetic field, possessing a component in the direction of the ray is known as Faraday rotation; the same phenomenon applies also to other forms of electro-magnetic radiation) in these films. With a packing density of 10^6 bits/cm^2, the writing field in a Mn-Bi film is about 10 Oe and the read-out rate around 10^9 bits/sec at 1 mW He-Ne laser power level.

A class of amorphous magnetic alloys called magnetic glasses has created considerable interest in recent years. Coupled with high mechanical strength, high corrosion resistance and

Fig. 7 Thin film thermopile consisting of 42 $Cu/Ge_{90}Cu_{10}$ elements capable of measuring temperature~10^{-3}K. (Developed at the Thin Film Laboratory, IIT, Delhi)



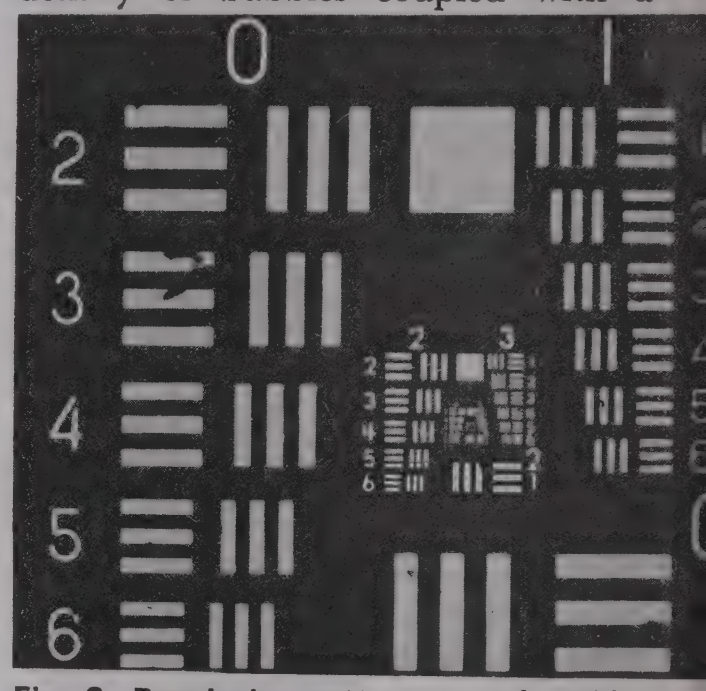


Fig. 8 Resolution pattern reproduced by photolithography on an amorphous $Se_{75}Ge_{25}$ thin (500 Å) film at the Thin Film Laboratory, IIT, Delhi

THIN FILM DEPOSITION TECHNOLOGY

Thin films are prepared by a variety of deposition techniques. They basically involve two physical processes : (1) the production of a beam of vaporised atoms and/or molecules of the desired material (source), and (2) the condensation (deposition) of the beam on the substrate at an " effectively " lower temperature (or higher supersaturation) than that of the beam. The deposition techniques are broadly divided into two categories: (1) Physical vapour deposition, and (2) Chemical vapour deposition.

Physical vapour deposition

The most common method here is thermal evaporation, which involves heating of a given material directly or indirectly to a temperature high enough to form a high atom density vaporised beam (typically 10^{16} or more atoms per cm^2 per second), with a sufficiently high vapour pressure. The material may be heated by placing it in a suitably shaped and electrically heated filament, basket or boat made of a high melting point and high resistivity metal such as tungsten, molybdenum or tantalum. To prevent chemical reaction with the material, the vapour sources (as these are called) are coated with ceramics such as alumina, zirconia, silicon carbide, etc. Alternatively, one may employ indirectly heated crucibles made of quartz, alumina or zirconia.

Thermal evaporation techniques are simple, clean and easy to control. Thermal evaporation can also be achieved by heating materials with a high-power CO_2 laser beam, or an energetic electron beam. In the electron gun, the electrons are generated by heating a tungsten wire and are then accelerated by a ten kilovolt potential. By employing a variety of electrostatic and/or magnetic focusing techniques, the powerful electron beams can be used to melt literally any material in almost a fraction of a second by dumping all the kinetic energy of the electrons into the material under bombardment. The sophisticated electron guns are thus very useful for high-rate evaporation of difficult-to-evaporate materials. Moreover, it is very convenient to employ more than one vapour source to

Fig. A A vacuum coating unit developed at the Thin Film Laboratory at IIT, Delhi

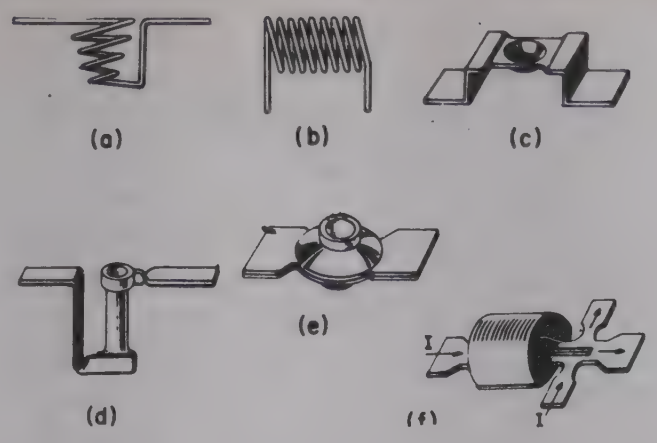


Fig. B Some thermal-evaporation sources : (a) basket, (b) spiral, (c) dimpled boat, (d) howitzer, (e) crucible heater, (f) dual boat, flash evaporation source

enable mixing of different materials to form alloys/compounds of desired compositions.

To eliminate the influence of ambient gas atoms on the vaporised beam of a material, it is necessary to perform the thermal evaporation in a vacuum system at sufficiently low pressure; such a system would ensure that the number of collisions of gas atoms with the vapour atoms or substrate is insignificant. Depending on the material to be evaporated and its sensitivity of reaction to the gas atoms, pressures of 10^{-6} Torr or less (10^{-10} Torr) are commonly used. A typical vacuum system fabricated in our laboratory for the purpose is shown in Fig. A. Such a system requires a host of gadgets to measure the pressure, the rate of evaporation and other physical conditions prevailing on the substrate. The rate of evaporation of a material is conventionally measured by measuring the ionised part of the beam as a current or by using a quartz micro-balance (a quartz crystal oscillator, the frequency of which changes on the addition of atoms to its surface).

Another powerful technique often employed to produce a vaporised beam is by removing the atoms/molecules of a material by bombarding its surface with high momentum ions of inert gases such as argon. This technique called " sputtering " (Fig. C) has many variants and, in principle, involves a high voltage direct current (or high frequency AC) discharge in a chamber filled with gas at a reduced pressure (of the order of tens of microns). The positive ions in the discharge are accelerated by an electric potential and allowed to bombard the material (target). The atoms of the material are removed essentially by a momentum transfer process and proceed outwards in all directions. Sputtering yields a diffuse vapour beam but one may obtain directed sputtering at low pressures by means of an ion beam.

Chemical vapour deposition

This category encompasses a very wide variety of chemical processes. Basically, any chemical reaction, or decomposition of a chemical (say, at high temperatures in which case it is referred to as pyrolysis) yields a product in vapour form. The decomposition may be effected by an electrochemical process (in which case it is called electroplating) or electrolysis (for metals), or anodisation (involving the reaction of oxygen ions with a metal). Although it is difficult to control the rate and purity, chemical vapour deposition is the cheapest technology for mass production of thin films. For example, pyrolysis of SiH_4 (silane) is a commonly used commercial process for the production of epitaxial silicon wafers for integrated circuit technology. Deposition of thin film of very high purity is industrially achieved by the process of electrolysis. And, aluminium oxide films (of different thickness and, hence, different colours) can be obtained by the wet anodisation process. Chemical reaction of two reactants at a high temperature substrate is the basis of the spray techniques used in the production of thin film CdS solar cells and conducting glass. Ingenious exploitation of suitable chemical reactions at or below room temperature, or adsorption of chemical constituents (particularly chains of a polymer dissolved in a solution) yield very interesting thin films by the so-called " solution growth techniques ".

What about substrates? The physical and chemical conditions of the substrate, needless to say, play a very important role in determining the structure of films. The chemical nature and the surface characteristics of a substrate are, however, dictated by the particular needs of a thin film. Single crystal substrates of NaCl, KBr, mica, MgO, sapphire, Ge, Si, etc, are used for epitaxial growth studies. Inert glass and ceramic substrates are commonly used for measurements of the physical properties on polycrystalline and amorphous films.

Numerous techniques also exist for the measurement of the thickness and surface profile of films. Such techniques include weighing (with a microbalance), interferometric, spectrophotometric and stylus (amplified movements of a diamond needle) methods. (For further details, the reader may consult the author's book *Thin Film Phenomena*, McGraw-Hill Book Company, New York, pp. 83-138.)

Fig. C A radio frequency sputtering unit developed at the Thin Film Laboratory at IIT, Delhi

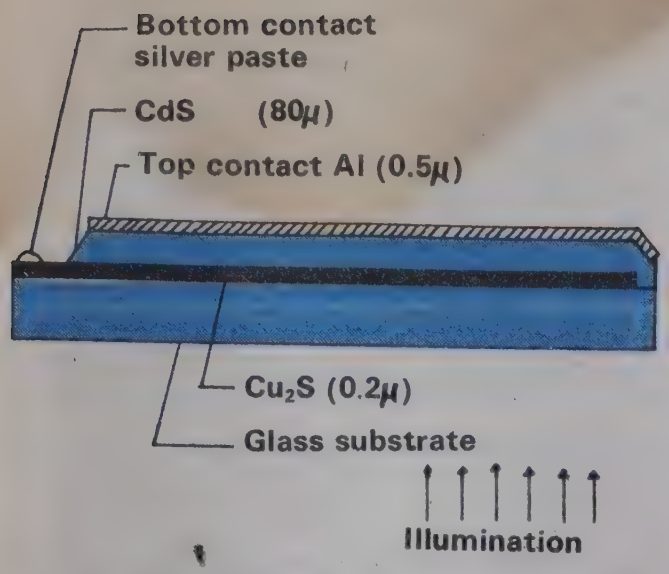


Fig. 9 Cross-section of a thin-film Cu_2S/CdS solar cell fabricated at the Thin Film Laboratory, IIT, Delhi

high magnetic permeability, some of these alloys (such as $Fe_{80}B_{20}$) have as small a coercive field (the magnetic field to which a ferromagnetic substance undergoing a hysteresis cycle must be subjected in order to demagnetise the substance completely) as 0·04 Oe and vanishingly small hysteresis losses (B-H loop). These materials, already available in thick foils, will, no doubt, have considerable impact on future electrical industry.

Achieving superconductivity at high temperatures (liquid air, if not room temperature) continues to haunt as well as inspire solid state physicists. On the basis of our existing knowledge, it may be speculated that thin film materials are the answer to high temperature superconductivity. Further, since superconducting currents are confined to the surface layer of a material, the electrical and electronic applications of superconductivity will be essentially based on thin films. Surprisingly, the most ordered quantum state (superconductivity is now well established as a macroscopic manifestation of the quantum effects) of a superconductor occurs *only* in the highly disordered and amorphous states of *some* materials such as Be and Cu-Ge. It has been observed that in amorphous films of tungsten and molybdenum, the superconducting transition temperature is considerably enhanced.

Of course, some of the most significant fundamental understandings of the phenomenon of superconductivity have resulted from the study of thin films. Among the major developments are the discovery of ' Cooper pair ' (pair of electrons) and the tunnelling of Cooper pairs between two superconductors connected by a very thin (tens of Angstroms) non-superconducting barrier film giving rise to a supercurrent. Besides providing a new generation of electronic switching devices (cryotrons), the Josephson effect of Cooper pair tunnelling and the related quantum interference effects offer us the most precise voltage standard and the values of some fundamental constants.

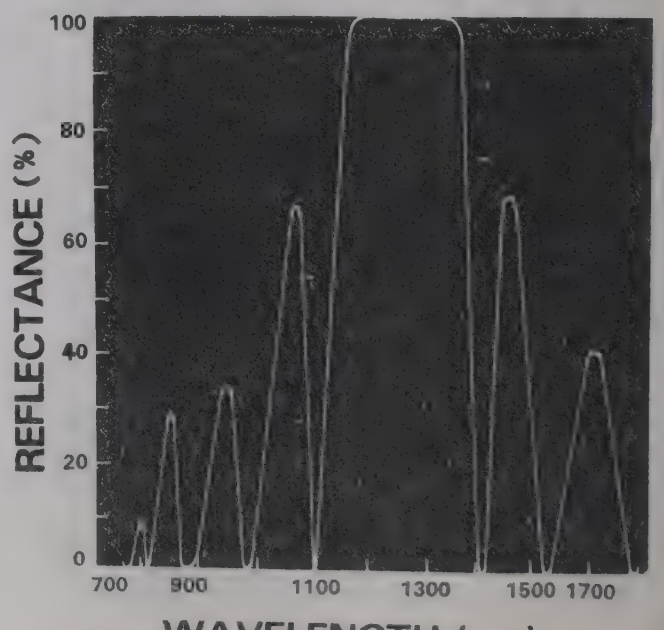
Epi layer (of silicon) is such a common name in the semiconductor world that both the scientist and the industry have forgotten that it represents the most significant commercial application of thin film technology. Epitaxially grown and well-oriented films of a number of semiconducting compounds find specialised applications in piezoelectric (surface wave), heterojunction, photoconducting, infrared and luminescent devices. The versatility of these electronic devices is enhanced by the possibility of alloying different thin film semiconductors to yield materials having a wide range of electrical, optical and physical constants. Thus, for example, we have prepared variable composition alloy films of PbS and HgS so that the optical band gap can be varied from 0·1 to 1·2 eV. This enables the fabrication of remote sensing detectors operating from visible to far infrared radiations.

Solar cells

Heterojunctions are currently the subject of extensive investigations for application in devices such as lasers and solar cells. Economical conversion of solar energy into electrical energy by photovoltaic mechanism will, no doubt, be possible with the help of large area thin-film solar cells made with polycrystalline semiconducting films. One of the leading contenders in this quest is the cheap thin-film CdS-Cu_2S heterojunction solar cell. It is not difficult to make such a solar cell of several square centimetres area and with conversion efficiency up to 8 per cent. But the real challenge is to preserve the life of the cell. Conventionally, such a cell consists of about 20 micron thick evaporated CdS film and 2000 Å thick Cu_2S film (obtained by chemical conversion of the surface layer of CdS). The Cu_2S film is unfortunately very susceptible to degradation due to the presence of a gradient of copper and/or oxygen. By the processes of oxidation, diffusion or electrochemical reaction, the Cu_2S continuously transforms itself to several other lower forms, Cu_xS, which are not suitable, optically as well as electrically, for efficient solar energy conversion. The solution to the problem lies in producing Cu_2S of exact composition. Alternatively, the structure may be stabilised with the help of an appropriate impurity. We have resolved this problem to a large extent in our laboratory by creating Cu_2S film by a solid state reaction between CdS and CuCl films (see SCIENCE TODAY, April 1977, p. 22). The structural stability and physical coherence of both CdS and Cu_2S films are further improved by special dopants. The solar cell so obtained is shown schematically in Fig. 9. We have obtained cells with four per cent efficiency and negligible degradation over a period of six months. Although there is a long way to go before a commercially viable thin-film CdS solar cell becomes viable, the versatility of thin-film techniques makes it a promising possibility.

The development of thin-film technology owes a great deal to the demands of the optical instruments industry, particularly the application of optical film coating to mirrors and interferometers. As we know, light incident on the surface of a glass is partly reflected and partly transmitted, the refractive index of glass being different from that of the surrounding medium. Thus, a considerable amount of light in a multi-component optical instrument is wasted by reflections at each glass-air interface. Both the brightness and contrast of the optical image can be improved by eliminating or reducing such unwanted reflections. Further, in some optical instruments, it may be desirable to transmit or reflect only selected wavelength(s). Another example is that of amplification of light in a gas laser which depends on multiple reflections of suitable wavelength(s) from nearly ideal mirrors (reflection interference filters). Optically coated lenses and mirrors improve the optics considerably in such cases. The cellulose film in a projector is saved from melting by the use of a specially coated lens capable of transmitting only the visible and not the infrared (heat) radiations from the projector lamp. By choosing films of suitable optical characteristics, it is even possible to regulate the inside

Fig. 10 Observed reflectance spectrum of a 20 period ZnS — MgF_2 film designed by Yadava *et al* (*Thin Solid Films*, 21, 297, 1974)



temperature of artificial satellites.

How does the optical coating work? It is based on the simple phenomenon of interference between light waves reflected from the front and back surfaces of a single film or a system of multilayer films. The phase difference between two waves depends on the angle of incidence, thickness and the optical constants (refractive index and extinction coefficient) of the film or its equivalent. By adjusting the optical thickness (a product of the geometrical thickness and the refractive index), waves may be allowed to interfere constructively or destructively at one or more wavelengths (as in the case of multilayer structures). One can design

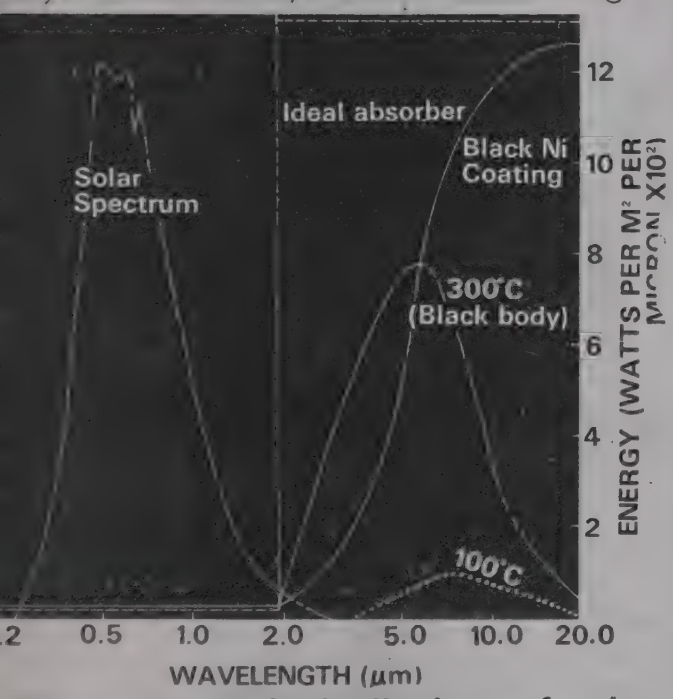


Fig. 11 Spectral distributions of solar and blackbody (at 300°C and 100°C) radiation. The dotted and solid curves show the spectral reflectance of an ideal photothermal converter and a black nickel coating, respectively, developed at the Thin Film Laboratory, IIT, Delhi

and construct a thin-film multilayer structure which will yield nearly 100 per cent reflectance or transmission at one wavelength (with half width as narrow as a fraction of an Angstrom) or a band of wavelengths covering hundreds of Angstroms. The characteristics of one such reflection filter are shown in Fig. 10.

The efficient conversion of solar energy into thermal energy requires a surface which absorbs solar radiation below about 2 microns to get heated, but does not re-emit (low emissivity) radiations in the infrared (beyond about 2 microns). This calls for "selective coatings" which are readily achieved with films of a mixture of a metal and a dielectric semiconductor (eg, black chrome/nickel/iron consisting of the metal and its oxides), tandem or superposed films of a low band gap semiconductor and a metal, or an interference type of multilayer (steel/Al_2O_3/Al) structure. The optical characteristics of one such selective coating, approaching an ideal behaviour, are shown in Fig. 11. Selective coatings offer the best hope of utilising the low-grade solar energy for thermal conversion.

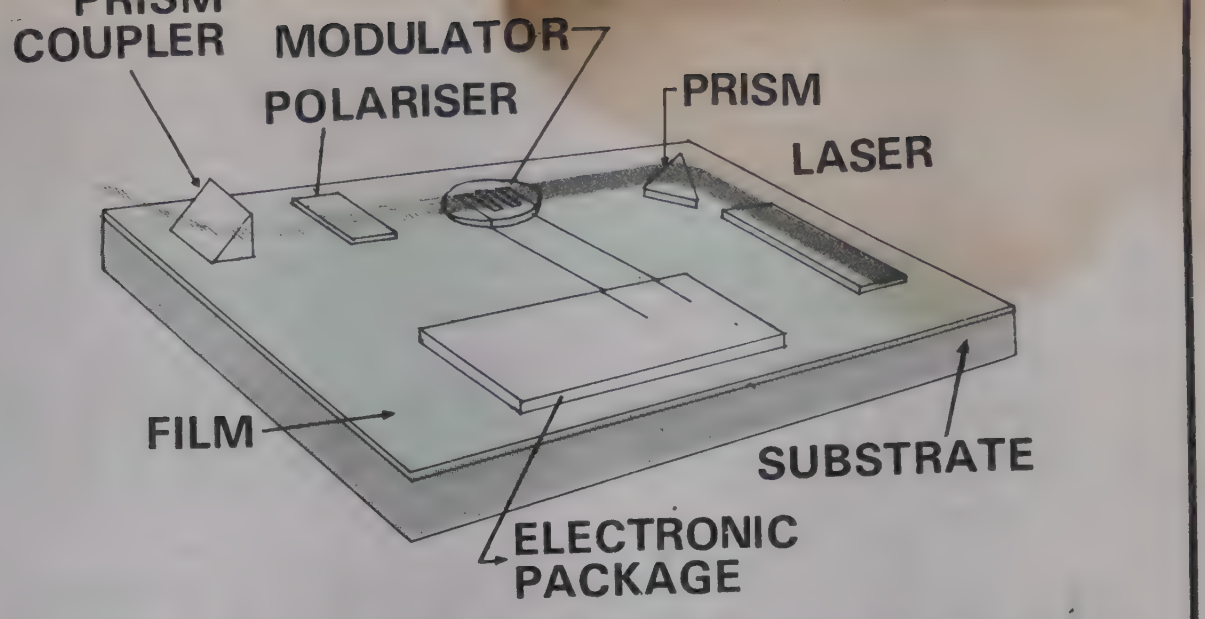


Fig. 12 Complete optical circuit made entirely of thin film devices may soon be fabricated on a substrate having an area of only a few square centimetres. In this circuit the light is generated by a tiny laser and directed around a corner by a prism, where it enters a magneto-optical switch. Signals from the small electronic package modulate the light, which then enters a polariser. The light wave, now modulated by the signals, can be coupled into a glass fibre and transmitted many km away for communication purposes. (P. K. Tien, "Integrated Optics", *Scientific American*, April 1974, p. 28)

The action of a lens, a prism, or a waveguide can be imitated by varying the refractive index spatially in any intricate geometrical fashion; the latter is achieved by varying the thickness or composition of a film. Similarly, anisotropic optical absorption characteristics can be built in films of suitable materials to obtain effective polarisation action. These micro-miniaturised optical components, together with thin-film lasers and optical modulation techniques, have ushered in the new era of "integrated optics" — a very convenient and desirable marriage of integrated circuits and thin-film optics. With integrated optics, scientists hope to achieve a major breakthrough in using the very large bandwidth optical communications network. This subject, however, is still a laboratory curiosity, but the progress is very encouraging. An example of an integrated optics device is shown in Fig. 12.

Needless to say, the small thickness of a film is no less important than its structure. A lot of work of fundamental interest in thin films is based on the thickness or "size" effects. The confinement of electrons (conduction as well as hot) within the surfaces of a film brings in a new dimension to our understanding of the electronic properties of surfaces. Moreover, it is the small thickness of dielectric and semiconducting films that allows us to study high field electron transport and optical effects. Thin-film resistors and capacitors of extremely high precision (a few parts per million) are now produced for use in analog digital conversion. As already mentioned, the thickness also plays a major role in determining the superconducting properties of films.

I should like to state here that most of the examples of thin films applications cited above have been taken from the work of my laboratory and, therefore, represent a somewhat biased interest. A number of other significant developments have not been touched at all for want of coherence and space. Nevertheless, it is abundantly clear that there are innumerable facets to the exciting and still emerging field of thin-film technology. It needs to be emphasised that significant achievements in the science and technology of thin films are only possible if the facilities and scientific skills of personnel in such diverse areas as vacuum technology, surface analytical technology, surface science, solid state electronics, and solid state physics are brought together. Unfortunately, this demands a very expensive and sophisticated laboratory manned by good broad-based scientist-cum-technologists. It is my view that although nuclei of thin-film laboratories have mushroomed in almost all our educational institutions and national laboratories, most, if not all, are subcritical and don't appear to promise any worthwhile advance in this area with their existing facilities.

A Senior Professor of Solid State Physics, and Dean of Post-Graduate Studies and Research at IIT, Delhi, K. L. Chopra has held senior R & D positions in Canada, West Germany and USA. He has established a school of Thin Film Physics and Technology at Delhi which has developed over a dozen processes/devices some of which are currently under production in smallscale industries in India. Prof. Chopra was recently awarded the S. S. Bhatnagar Prize in Physical Sciences for 1975.

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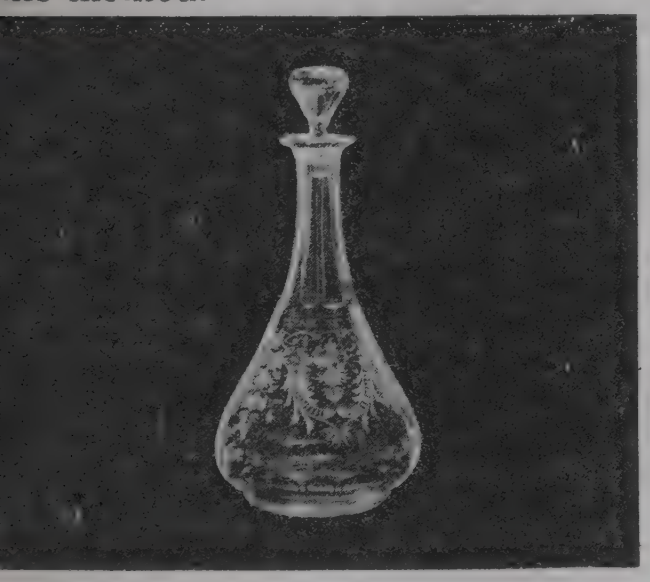
NUCLEAR DATING

Nondestructive Dating of Glass Objects

A method of dating or authenticating man-made glass objects has been proposed by Dr. W. A. Lanford of the Department of Physics, Yale University, New Haven, Connecticut, USA, in an article in *Science* (**196,** 975, 27 May 1977). The report, in fact, includes only some preliminary tests he has conducted as an exploration of the potential of the method.



The dating of glass objects, no doubt, has an historical value since glass has been used for thousands of years. Glasses are unstable with respect to reactions with water. On exposure to atmospheric water, the surface of glass begins to hydrate. Glass is primarily a three-dimensional matrix of silicon and oxygen atoms, and it is the Si-O-Si chain which reacts with water to form the hydrate. The rate of hydration depends on the rate of diffusion of water into the glass, which is extremely slow. The relation between the thickness of the hydration layer, X, and the age of the sample, T, is given by $X^2 = KT$, where K is a constant. K would depend on the composition of the material, the method of manufacture and the environment in which the sample remains.

Obsidian, a natural volcanic glass that was used by ancient man to make arrowheads, knives and other tools, also hydrates like ordinary glass, but with a difference. Since hydrated obsidian has a specific volume different from unhydrated obsidian, unlike man-made glass objects, there is a stress line between the hydrated and unhydrated regions that appears as a dark line on illuminating the sample with polarised light. But optical measurements on obsidian require cutting, mounting and polishing a thin cross-section of the surface. Art historians, understandably, would not like their objects to be destroyed.

The proposed method of Dr. Lanford is based on a resonant nuclear reaction between nitrogen-15 and hydrogen, yielding a characteristic gamma ray. The yield is proportional to the hydrogen concentration at the surface. At energies above or below this resonance energy, the yield from the reaction is negligible. But, as the energy of nitrogen-15 is raised, it loses energy on passing through the sample, and the resonance energy is again reached at some depth. The yield of gamma rays is then proportional to the concentration of hydrogen at this depth. Hence, by measuring the yield of characteristic gamma rays versus the energy of nitrogen-15, one can determine the concentration of nitrogen as a function of depth. In his experiments, the sample was bombarded with nitrogen-15 from an accelerator.

Dr. Lanford with his technique has measured the hydration thickness of American glasses of known ages (less than 200 years old) and shown that qualitatively the relation between age and hydration thickness holds true. He contends that a detailed study of the composition dependence of K may make it possible to develop a quantitative dating procedure. According to him, his method will prove most useful in authenticating glass objects.

The results are preliminary in that he has shown the potential of the method only in some recently produced glass, but, he claims, there is no reason why the method cannot be applied to ancient glasses. However, one pitfall is that the surface corrosion present on excavated glasses may make reliable hydration dating difficult. Adding a futuristic note, he says that the glazes on pottery are chemically similar to glass, and it may be possible that a dating method for glazed pottery based on the resonance technique can be developed.

ORNITHOLOGY

Do Birds Navigate Using Magnetic Fields ?

How birds navigate continues to be a topic of investigation and discussion. Various methods have been suggested — the Pole Star, the Sun compass, sense of smell, magnetic fields, etc. Some support to the contention that birds navigate by using the earth's magnetic field has been provided by Dr. F. R. Moore, a zoologist at the Clemson University, South Carolina, USA. The novelty of his investigation is that he has used direct visual observations on free-flying birds, whereas most of the evidence that birds extract directional information from the geomagnetic field has come primarily from controlled cage experiments with passerines and non-passerines and from homing experiments with pigeons. The details of his study are reported in *Science* (**196,** 682, 6 May 1977).

He has used data on passerine birds collected by S. A. Gauthreaux, Jr., during the spring and fall of the years 1968 through 1974 in the south-eastern United States. The latter had devised a technique called the ceilometer watch where the direction of movement and number of migrants passing through vertically directed beams of light are noted. Moreover, Dr. Moore has analysed the influence of magnetic fields on birds that migrate at night when magnetism might be more important (previous studies have found a relation between the flight direction of day-time migrants and geomagnetic disturbances, but the results have been questioned, since during the day the Sun compass dominates).

Dr. Moore had compared the migrating birds' orientation with the short-term fluctuations of the earth's magnetic field. He found that the more intense the geomagnetic disturbance, the greater is the spread or variation in the birds' paths. In the spring, the vertical component of the magnetic field was found to be the important variable. In the fall, the horizontal component was the important variable. Fluctuations in the declination of the magnetic field were found to have no effect, regardless of the season.

Dr. Moore claims that he has demonstrated a strong correlation between the orientation of the free-flying nocturnal migrant birds and geomagnetism, but whether the magnetic disturbances act directly or indirectly on the birds' orientation system is not clear. In any case, nobody, Moore included, knows how birds can sense magnetic fields. Hence, he concludes that though the results indicate that geomagnetic disturbances influence the orientation of free-flying migrants, the evidence is not sufficient to show that geomagnetism is a cue in their orientation system.

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AIR-INDIA

GEOPHYSICS

Artificial Pulsating Auroras

Auroras, popularly known as the ' northern lights ', not only fascinate observers but continue to be objects of intense investigation by geophysicists. They are known to be produced when electrons precipitated from the radiation belts interact with the atoms in the upper atmosphere. But, they come in a variety of forms and very little is known of the detailed mechanisms by which such forms are produced.

Drs. C. Deehr and G. Romick of the Geophysical Institute, University of Alaska, Fairbanks, Alaska, USA, have now produced what are called pulsating auroras by releasing barium vapour into the upper atmosphere (*Nature*, **267,** 135, 12 May 1977). These are rare phenomena consisting of irregularly shaped patches of light some 10 to 50 km in extent that appear to turn on and off regularly with a period of the order of 10 seconds. They had previously been observed predominantly at altitudes below 100 km. High energy electrons, between 10 keV and 60 keV are usually involved.

The electrons causing the auroral displays would, no doubt, be affected by electric and magnetic fields and by the wind in the upper atmosphere. The Alaskan scientists were, in fact, measuring the conventional parameters in an aurora in the polar regions, when they discovered the completely unexpected pulsating aurora. The technique was to fire a rocket to an altitude of 250 km (F region of the ionosphere) and then explosively release from a canister a cloud of barium vapour. Sunlight interacts with the cloud to ionise it partially, to form a cloud of ions which resonantly scatters purple light from the Sun, and a neutral cloud which scatters green light. The neutral cloud is blown across the sky by winds while the ionised cloud is driven by the combination of electric fields and winds. Tracking both clouds optically from the ground provides information of the winds and electric fields at an altitude. The barium release technique is being used at Thumba, Kerala, to study the upper atmospheric conditions over India.

The unexpected finding of the Alaskan scientists is that when the cloud was released above the diffuse glow of a natural aurora, it induced pulsating auroral displays beneath the cloud. The release reported by them is the only one to take place within a significant amount of natural aurora and its presence seems to be a necessary condition for the pulsations. The artificial pulsations were found in one of the natural auroral spectral lines at 200 km altitude, where electrons of 500 eV deposit most of their energy.

The importance of their findings is that it may now be possible to generate pulsating auroras artificially, so that the mechanism of their production can be studied in detail. The speculation is that the beam of electrons is modulated by some plasma wave on its way down the magnetic field lines from the outer radiation belt.

MEDICINE

Is Cowpox Caused by Cows ?

Cows need not be the natural reservoir of cowpox. This is the major conclusion of a review of 10 confirmed human cases of cowpox made by Dr. Derrick Baxby of the Department of Medical Microbiology, Liverpool University, Liverpool, UK. The details of his study are reported in the *British Medical Journal* (**1,** 1379, 28 May 1977).

Cowpox has been traditionally regarded as an occupational disease of dairy farm workers. Most workers assume that the cow is the natural host and reservoir of cowpox virus, although the possibility of some unknown wild animal or bird being the host has been raised. There have also been reports of isolated cases of human cowpox in which contact with cattle was not established.

Dr. Baxby has reviewed 12 separate cases of confirmed cowpox infection (10 of them in man) occurring in 1965–76 in an attempt to provide information on the natural history of the disease. There was no connection between them, and they occurred in different places at different times. Six of the patients including three children had severe infections and five were admitted to hospital. In five cases, cows were found infected and in three, farm workers were also infected. In three cases, both men and cows were infected, but how the latter acquired cowpox could not be determined. In seven of the human infections, enquiries failed to establish direct contact with cattle, although all of them had lived in or visited rural areas. Clinical and serological examination failed to show evidence of cowpox in the cattle. Indirect infection from cattle was, therefore, unlikely and, in addition, none of the patients had been away from home, at the time the infection occurred.

The Liverpool microbiologist states that his observations, together with other information about infections known to be enzootic in cattle, lead to the suggestion that cows are not the natural reservoir of cowpox. It is possible that both cows and humans become infected accidentally — cows from the reservoir and man either from the cows or the reservoir. According to him, the reservoir could be some small wild mammal. He, therefore, advocates that the role of small wild animals as hosts and vectors of " cowpox " should be investigated.

Another interesting point, not concerned with Dr. Baxby's work, is that the World Health Organisation has recently claimed that it has wiped out small pox from India and many other countries of the world. But some workers suspect that the small pox virus may also be carried by animals, though at present latent, and the infection may appear again in humans.

K. A. NEELAKANTAN

" Our future depends on you, Bunny ! It's either the Academy of Sciences or the Magician's Guild."

Sushma

on scientific breeding of goats

R. R. MISHRA

The goat is a multipurpose animal. It yields milk, meat, skin, mohair and pashmina. Goats are closely related to the sheep and the domesticated varieties are widely distributed throughout the world. Seventy per cent of the global goat population of 383 million resides between latitudes 30° north and south. India alone possesses about one-fourth of this (68 million). The goat population of India accounts for more than half of that in some representative countries of the tropics and subtropics (Table I). The goat is often spoken of in our country as the " poor man's cow ", and it has probably assumed an added importance because of its association with Mahatma Gandhi.

Docile in nature and cleaner in habits than cows and buffaloes, goats are quite popular as milch animals in Switzerland, France, England and the USA. But, we have only eight to ten million goats which can be considered suitable for milk production; their annual milk yield is less than one million tonnes. In India, goats with one to five kg of milk yield per day are rare, but there is no reason why such goats cannot be produced in millions with proper scientific breeding.

Apart from the milk they yield, other advantages of goat breeding and husbandry are the meat obtained from male kids and old does as well as the costly hair (mohair, pashmina) from their body coat. Goat meat (chevon) is highly preferred, since its fat is mostly concentrated near the viscera and the meat is less marbled than that of other animals. The demand for goat meat in India, at present, exceeds the supply. Goat skin (leather) and blood albumin are other products gaining popularity.

Goat's milk is especially valuable since it resembles human milk more closely than does the cow's, the sheep's or the buffalo's (Table 2). One important characteristic is that the casein in it, during digestion, forms a less tough and more friable coagulin than does the casein in cow's milk, so that digestive proteolytic enzymes penetrate and break it down more rapidly. The other characteristic is the smaller fat globules, which make it easy to digest and, hence, important in the nutrition of infants, invalids and convalescents, especially those suffering from chronic diseases and digestive upsets, or who are allergic to cow's milk. Its curd and other products are also easily digestible. Again, the bacterial count of hygienically produced goat milk is lower than that of milk from other species. This is why Hippocrates, " the father of medicine ", is said to have advised its use during many human ailments.

A healthy goat yields one-fifth of her body weight per day as milk, or 10 to 15 times her weight in a lactation period of 200 to 250 days. A dairy goat, in fact, may be considered as a hygienically stored milk-pot, as it can be trained to let down milk any time of the day. However, two to three milkings a day in regular hours is advised. Goats are at their prime at four to six years of age, but can continue to give a good quantity of milk until they are nearly 12 years old. Normally, a goat

Table 1 : Livestock population and the importance of goats as compared to cattle and sheep in representative countries of tropics and sub-tropics (FAO, 1971)

Country	Population in thousands			Ratio between species		
	Goat	Sheep	Cattle	Goat	Sheep	Cattle
India	68,000	42,800	176,600	1	0·6	2·6
Indonesia	7,000	3,750	7,200	1	0·5	1·0
Iraq	2,500	14,000	1,920	1	5·6	0·8
Jamaica	380	013	270	1	0·3	0·7
Mexico	8,468	5,321	25,124	1	0·6	3·0
Nigeria	23,500	8,100	11,600	1	0·3	0·5
Turkey	19,483	36,471	12,756	1	1·9	0·7

Table 2 : Comparison of goat, cow, buffalo, sheep and human milk

Milk animal	Milk contents (%)				
	Water	Fat	Lactose sugar	Protein	Ash
Goat	86·88	4·07	4·64	3·76	0·85
Cow	86·27	4·68	4·94	3·39	0·74
Buffalo	82·22	7·65	4·82	4·37	0·94
Sheep	83·57	6·18	4·17	5·15	0·93
Human	87·58	3·74	6·37	2·01	0·30

reaches her highest yield in her second or third lactation, and she attains her peak yield in about 45 days after kidding. On the whole, the cost of production of goat milk is lower than either the cow's or the buffalo's milk.

One common complaint, however, about goat's milk is its peculiar smell. But this can be easily overcome by hygienic milking, straining and cooling of the milk. Destroying the musk gland and keeping the buck away also alleviates the bad odour. In any case, a consumer, selected at random and offered the choice of hygienically produced unlabelled samples of goat's milk and cow's milk, can seldom distinguish one from the other and may even choose the goat's milk.

Scientific management

The economics of goat-keeping, however, depends a great deal on scientific management. It involves proper breeding, proper feeding, proper housing as also looking after the herd-health, care of the young, care of the common ailments and diseases, cleanliness, etc, and a hygienic milking procedure. The best management, no doubt, is one which leads to higher production and economic out-turn.

Goats, so far, had developed through genetic isolation and natural selection. Their purposeful breeding, based on such selection factors as their general longevity and production capabilities, is a somewhat recent phenomenon. What a pedigree breeder needs most is a knowledge of both genetics and the various desirable strains he could make his choice from. His first consideration, evidently, will be the vitality and good health enjoyed, generally, by a breed. The second will be a stock's known capacity for milk production — its inherent milking capacity, feed-intake capacity and feed-to-milk conversion efficiency. A well-chosen breeding male can, indeed, influence a whole range of succeeding generations.

Once the breeding males have been selected, they are kept separately from the age of four months. A young female goat is first mated when she is about six months old, provided she has gained weight. A mother goat may come into heat again a month or two after kidding, when she could be mated again. A female, thus, can be made to kid twice a year.

The task of evolving new breeds by crossing local does with exotic bucks suitable for different agro-climatic conditions of India has been taken up under the All India Coordinated Research Project on Goats for milk, meat, mohair and pashmina. The prominent breeds of milch goats in the world are the Saanen, the Alpine, the Toggenburg and the Anglo-Nubian (see box on p. 27). And of the 21 goat varieties of India, the principal dairy breeds are: Jamunapari, Beetal, Barbari, Surti, Marwari and Osmanabadi. The present plan is to produce contemporary pure-bred locals and cross-breds with one or two exotic breeds (Alpine, Angora, Saanen, Predonskaya) depending on the location and the requirement.

Feeds and feeding

The goat is a ruminant, but its feeding habits are unlike those of sheep and cows. For its size, a goat consumes substantially more feed than either a cow or sheep, namely, 6·5 to 11 per cent of its body weight in dry matter, compared to 2·5 to 5 per cent in the case of cattle and sheep. Goats can satisfy their maintenance and production requirement on good fodder and pasture. It is interesting to note that a 45-kg body-weight goat requires 1·5 times as much feed per day for maintenance as would a cow of equivalent weight. For every 63 kg of feed consisting of common concentrates mixture, a goat has been shown to produce a decalitre more milk than a cow. As a rule, the goat should not be fed more than 50 per cent of dry matter as concentrates. The remainder of the ration should be roughages. (The leaves and stalks of plants rich in crude fibre form roughages, while grains and its by-products containing less crude fibre are concentrates.)

The roughages should be supplied in the form of hay, silages or roots (carrot). Good quality proteinous legumes like lucerne (alfalfa) or berseem hay is more desirable for milking animals. A proper concentrate mixture essential for the milking doe is composed mainly of cereal grains, including maize, oats and barely. However, to supply a properly balanced ration, these cereals have to be supplemented with protein-rich

Table 3 : Apparent digestibility of various dietary constituents by goat, sheep, cattle and buffaloes on same diet (grass + groundnut cake, fed at 8 per cent of metabolic live weight)

Feed constituents	Goat	Sheep	Cattle	Buffalo
Dry matter	59·7	59·9	53·5	54·1
Organic matter	64·0	62·6	56·4	56·9
Crude protein	66·4	64·1	49·5	47·5
Ether extract	71·2	73·4	62·9	74·1
Crude fibre	66·9	64·3	61·6	62·0
Nitrogen free extract	60·9	60·2	52·9	53·2

concentrates (vegetable oil cakes), minerals and, occasionally, vitamins.

Goats prefer coarse feed—cracked, coarsely-grounded grain. It is advisable to keep a block of trace mineral salt available all the time. As goats enjoy and need plenty of fresh water, they should not be allowed to drink from pools of stagnant water.

Housing

Proper housing for them is also equally important. They may be kept under wide shady trees, where available. But, it is preferable to house them in a shed or small barn which is also well-lighted and well-ventilated. The shed must be clean, dry and free from draughts. Dampness is dangerous as goats easily catch cold which may later develop into pneumonia (one of the few diseases to which goats are quite susceptible). Cheap houses with low roofs and large corral, hanging hay tracks, water buckets, concentrate trays, kid boxes and raised platforms with narrow drains are pre-requisites for the proper care of the milking does. The ideal width of the shed is 3 m to

A Barbari buck

DAIRY BREEDS

The Saanen breed is the milk queen of the goat world and has its home tract in Switzerland. Its coat colour is white, but sometimes it is cream or grey, particularly fawn at the spine. They do not as a rule carry wattles or tassels. The world lactation record in goats (305 days) is held by a Saanen goat in Australia, with a yield of 3,084 kg milk (3·3 per cent fat). A mature doe and a buck weigh 50 kg and 70 kg, respectively. Udders are usually shapely and well hung. The daily average yield of milk is 3 kg with an average lactation yield of 847 kg in 250 days.

The coat colour of the Alpine breed varies from black and fawn to white. The breed includes mainly heavy milkers (over 1,000 kg in 240 days), but butter fat and body weight average the same as with the other breeds of goats. The daily average yield of milk is 2·5 kg with an average lactation yield of 575 kg in 247 days. A doe weighs 50 to 60 kg and a buck 65 to 80 kg.

The Toggenburg breed originated in the valley of Toggenburg in Switzerland. Its coat colour varies from deep chocolate to pale-drab with light fawn or white markings down each side of the face and from the knees or hocks to the feet, around tails, rump and thighs. The ears are small and pricked. Two wattles or tassels are present at each side of the under parts of the neck. They are usually hornless, and the members of the breed are not very good milkers. Their average milk yield is 2 kg with 3·4 per cent butter fat. The lactation yield is 800 kg in 200 days. Kids at birth weigh 3 kg, the mature does, 45 kg, and bucks, 60 kg. This breed is better suited for adaptation in India.

The Anglo-Nubian breed has resulted from the product of crosses involving Egyptian (Zariby), Indian (Jamunapari), Swiss (Toggenburg) and the old English-type goats. The Anglo-Nubian may be of any colour varying from the solid white to beautiful, marbled and spotted specimens in hues of fawn, black and grey. Big animals, they are consistent milkers with milk containing 5 per cent fat and 10 to 11 per cent solids-not-fat, and are usually called the "Jersey" of the goat world. On an average, they yield one kg milk per day. The lactation yield is about 300 kg in 300 days. The mature females weigh 40 kg and males around 60 kg. Milk from the Nubian breed is claimed to be cheap and best in quality.

Indian breeds

The Jamunapari is common near Etawah and Agra districts in western Uttar Pradesh. The coat colour is white with chestnut or light brown neck and face. However, goats with patches of tan or black are not uncommon. They are tall and leggy, with large folded, pendulous ears and convex face. The average weight of a mature female is 50 kg and that of a male 80 kg. The average milk yield is one kg per day with a lactation average of 196 to 272 kg in 210 to 283 days. The maximum yield reported is 4·85 kg per day and 544 kg in 250 days.

The Beetal belongs to the Punjab. They are large-sized goats with black and sometimes red coat colour, many with heavy white spots on the body. The eyes are black/blue with white or brownish corneal surroundings. The ears are large and hanging downwards. The face is convex. The wattles or tassels are generally present in pairs. Bucks mostly carry a tuft of hair under the chin known as beard. A mature female weighs 45 to 50 kg and a male 56 to 80 kg. The average yield of milk is one kg per day with a lactation yield of 107 to 288 kg in 160 to 244 days.

The Barbari is called the dwarf milch goat of India, mostly found near Agra, Mathura, Etah and Aligarh districts of Uttar Pradesh. They have very fine white fawn coat of short and silky hair. The ears are slender, rather small and stand erect from the head. The facial line is almost straight. The legs are short with strong and fine bones. The outstanding quality of the breed is its habit of stall feeding, which makes it most suitable for towns, where grazing facilities are lacking. The mature females weigh 25 to 30 kg and the males 35 to 45 kg. The average milk yield is 0·7 kg with a lactation yield of 101 to 228 kg in 210 to 252 days. They are considered prolific breeders, kidding twice in 12-15 months' time.

R.R.M.

AN ECONOMIC HOBBY

Goat-keeping, formerly a side-line, is becoming more economical for the masses with the reduction in arable land area and with the availability of adequate labour. It can serve as a smallscale rural industry for landless labourers. A shepherd community (Gadaria) can profitably keep 25 to 30 goats to support the family and as a source of extra income. Goats can be managed by marginal farmers on small acreages to provide food for the family and for income. The owner can build up the fertility of his land with the manure.

Goat-keeping can also be developed as an important side-line activity for women and children. Apart from providing pleasure and profit, it can develop in them a sense of responsibility and confidence by using the resulting money to buy their own clothes, school supplies or to start a bank account. Everyone knows that kitchen garden is a great asset for the family and goats are easy to keep on kitchen garden wastes. It can provide a wholesome and healthy environment in which to rear children. They can be given chores that are adapted to their age and ability.

Goats can also benefit part-time rural and urban workers whose numbers are rapidly increasing. Many industries offer only seasonal work, and, in slack seasons, employees can make goat-breeding profitable. Workers from certain industries who tend to suffer from hypertension can live on the edge of the town and take to goat-keeping. This could prove interesting and profitable, provide food and recreation, and, by diverting the mind from the daily grind, cure tension and fatigue.

Hints for beginners

The profession of goat husbandry should be started in a small way to get a first-hand experience and then developed only as fast as it proves to be profitable. It is better to start with a few goats and gradually increase the number as one's knowledge of care and management increases. Problems are bound to arise but remedies would be found with experience.

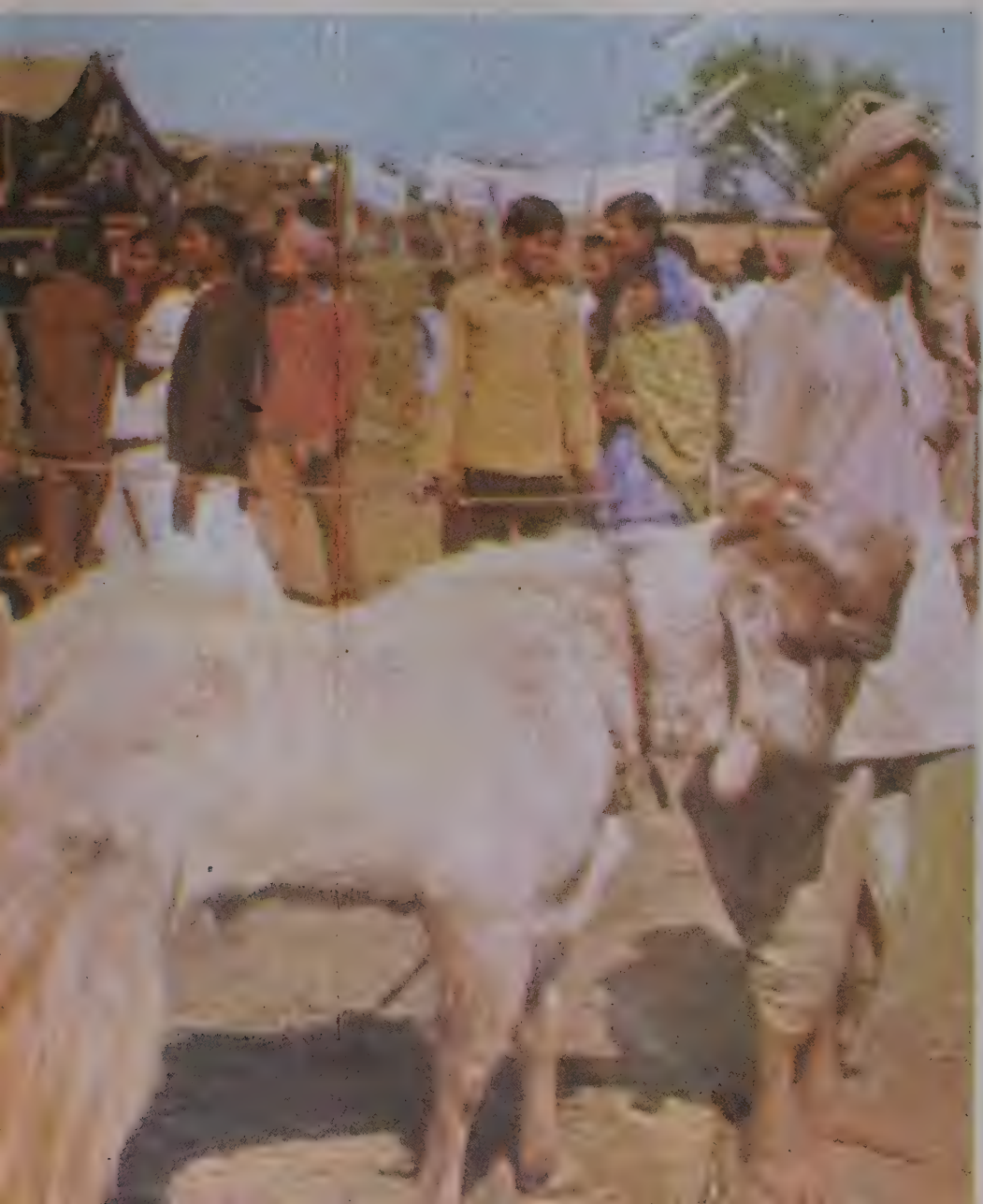
Success will depend on how carefully and intelligently the right breeding stock has been selected. In selecting a doe, the first question that will arise is: how much milk will she produce and how long will she milk? While some does milk for only a few months after kidding, others continue producing milk for 8 to 10 months or even longer. It is good to avoid does that are fleshy. They are bad milkers. Again, owing to scarcity of good goats, it is economical to purchase the local variety and cross it with well-recognised breeds.

Remember goats are easy to house and feed. They require only shelter enough to protect them from rain and wind. A pen of a square metre area will be large enough for two goats. It should be so constructed that the feeding bin or boxes, hay manger and water supply are outside. The dirt inside should be cleaned out daily and goats groomed to keep them clean.

Goats, as has been stated already, are easy to feed. Ordinarily, one milk doe requires one-sixth to one-eighth of feed required by a cow. Milking goats require six to eight kilograms of fodder and 300 to 400 grams of concentrates per day.

3·6 m, with a manger, 38 cm wide, running through the centre. Goats are tied on either side and about a square metre of space should be allotted to each goat. The milch goats, specially, should not be allowed to run together in their pens for getting roughages and concentrates. They are preferably fed in separate stalls or in a group of 8 to 10 does. It is better to house them in groups of 30 to 40.

Protection from common diseases forms another important area of scientific management. The following ailments are quite frequent among goats: pneumonia, tympany (acute form of indigestion), entero-toxaemia, acetonaemia, pregnancy toxaemia, eye



A Jamunapari buck at a livestock fair at New Delhi

Centres of research in goat breeding in India

For milk:

(1) National Dairy Research Institute, Karnal (Haryana)

(2) Kerala Agricultural University, Trichur (Kerala)

(3) Assam Agricultural University, Khanapara (Assam)

(Started for developing milch goats in 1971, has changed to developing meat goats in 1976.)

For pashmina and mohair:

(1) Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra)

(2) Indian Veterinary Research Institute, Mukteswar (UP)

(3) Leh Unit, Ladakh (J & K)

For meat [chevon]:

(1) Rajendra Agricultural University, Chotanagpur Centre (Bihar)

(2) R.B.S. College, Agra, UP

(3) Central Sheep and Wool Research Institute, Avikanagar (Rajasthan)

Goats come in heat regularly between September and March. They usually remain in heat for one to two days, the period between the heats varying from 5 to 21 days. The gestation period averages five months. Usually two kids are born, but sometimes there may be even three or four. The new-born kids need special care. They should be cleaned, dried and fed colostrum (the first milk) as early as possible, preferably within one to two hours of birth. After the kids are a week-old, milk should be fed at 8 to 10 hours' interval and they should be encouraged to take green feeds, concentrates and leaves. When they are 3½ months of age, feeding of milk in the night should be stopped. Milk feeding should be stopped completely at four months (or 15 kg body weight). Male kids should be separated at the age of 2½ to 3 months; castrated male kids may, however, be allowed to run with female kids. Tattooing, disbudding (removing the horn buds from kids is a common practice and should be done when they are two to five days old), grooming and hoof-trimming are modern aids to management and should be adopted.

R.R.M.

A flock of goats at NDRI, Karnal

troubles, worms (tape worm, round worm, lung worm, ring worm, etc), diarrhoea, constipation, caked udder, lice, foot-and-mouth rot and sore teat, leading to blood in milk, and mastitis. Prophylactic measures include routine vaccination of kids at three months of age, and routine deworming at three-month intervals — preferably before and after the monsoon season. Periodical test of the flock against tuberculosis, brucellosis and parasitic worms are recommended. Caked udder or mastitis should be treated by fomentation with Epsom salt solution followed by application of Iodex or lard. Foot-and-mouth rot comes mostly in the rainy season. Soaking the affected area with saturated solution of copper sulphate and application of pine tar promotes healing after infection has been controlled.

Good care and management can prevent many of these diseases. Goats like to eat clean food and stay in clean, well-ventilated quarters; they also like to have an occasional bath in warm sunny weather. Cleanliness is the first principle of good health and goats co-operate fully in this endeavour. It is necessary to keep a sick goat warm and free from draughts by separating it from the healthy stock. A warm bran gruel may stimulate appetite under sick or debilitating conditions.

Goats are intelligent animals. They readily adapt to a particular environment, or a system of feeding or management, but they are also sufficiently mischievous to take advantage of any carelessness on the part of their owner. Mostly mismanagement, and not an inherent fault, is the cause of their alleged destructive habits.

Goat breeding and husbandry are, in fact, ideally suited to our rural economy. Dairy goats not only fit easily into the environment and socio-economic conditions that may be quite unsuitable for dairy cattle or buffaloes, but by regulating their breeding, they can also be made to yield sufficient milk for an average family of four to five members. It is possible to keep two goats for about one-fourth the cost of keeping a cow. They are of small size and have inquisitive feeding habits. They feed on leaves, kitchen waste, vegetable offals and graze on nearby fences. They have a high digestive efficiency for cellulose, high efficiency of feed utilisation, high fertility, prolificacy and short gestation interval. On an average, a goat will produce five daughters in eight years, while most cows and buffaloes are not able to produce five daughters in their lifetime.

An Alpine x Beetal cross-bred doe evolved at NDRI

Dr. R. R. Mishra is a senior scientist at D. C. G. Division, National Dairy Research Institute (ICAR), Karnal. His fields of specialisation are animal genetics, breeding and production.

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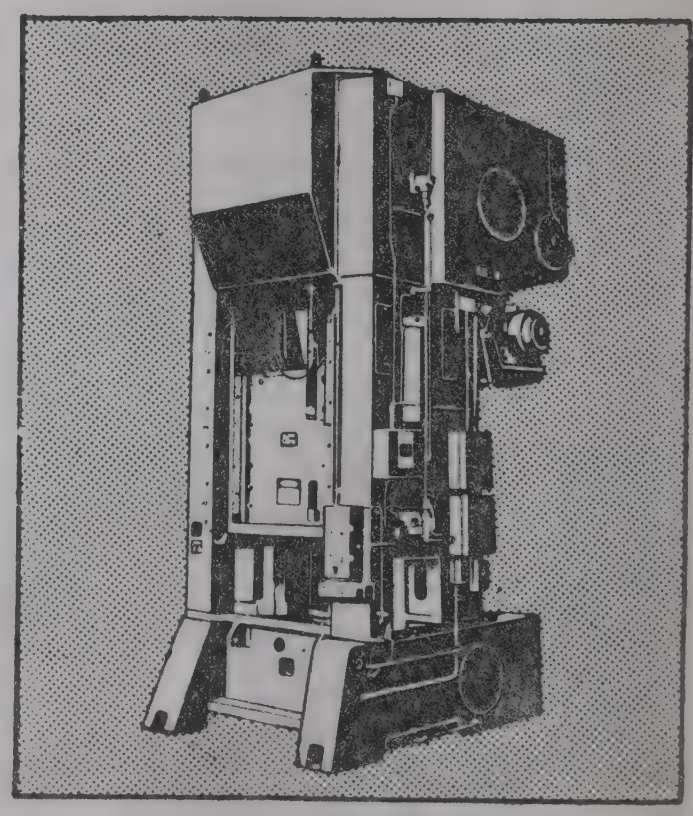

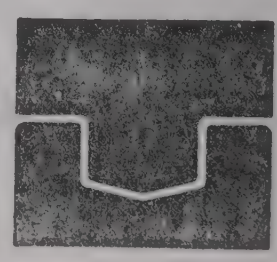

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Tamarind tree

LET'S GET TO KNOW OUR TREES!

Village Trees

It's an ancient tie that binds village life in India to the trees — be they in planted groves, on the borders of cultivated land or on forest fringes. Trees surrounded hermitages and were well cared for and preserved. In fact, the antiquity of some of our trees can be traced to references in folklores and legends, in tribal songs and in our immortal epics, poems and plays.

Tribal populations in many regions of our land have looked upon trees with a certain respect and, in some instances, fear, believing them to be the abodes of good spirits or evil. This may, perhaps, account for why some trees near villages have been allowed to survive when large tracts of forest flora have been devastated and laid bare to make way for new settlements and cultivated land.

A very common but beautiful tree seen throughout India (from the sub-Himalayan tracts to Kerala) is the **tamarind** (*Tamarindus indica*). The tamarind is originally a native of the Sudanic region of tropical Africa; the period of its introduction into India is not known with certainty, though it is thought to be quite far back in time. (Some authorities believe that it is also indigenous to South India.) Its nativity notwithstanding, the tamarind has come to be recognised as an Indian tree, so much so that its common as well as scientific name is derived from the Persian "*tamar-i-Hind*" meaning "date of India".

Though usually planted around villages, the tamarind has also run wild in some places because its seeds are dispersed in many ways including transport by water. It is often planted as a roadside or avenue tree. It has a thick greyish trunk with a girth of up to seven metres and may reach a height of about 25 metres. The crown, which is dense and many-branched, is composed of paripinnate leaves with 10 to 20 pairs of small leaflets. The tree is evergreen, but during the summer, there is an abundant leaf fall along with sprouting of new leaves in March and April. The small flowers appear in profusion between April and June but often go unnoticed being hidden by the leaves and often because of the great height. These little flowers reveal their remarkable beauty when freshly gathered and examined with a hand-lens: four creamy sepals, three unequal pale petals with a red filigree network of red veins, three green stamens and the single long pistil curving out of the centre.

The tamarind fruit is a pod about 10 to 20 cm long containing anything from three to 12 seeds. The seeds— dark brown in colour and each covered by a thick membranous envelop — are embedded in the red-brown fibrous pulp in the ripe pod. The pods, green when raw and covered with a rough buff coating ripen in the cold season. The tree is propagated from seeds, and in about 13 or 14 years starts to yield fruit and continues to do so for over 60 years. The long life of the tamarind tree is acknowledged in a tribal song of the Gonds of Central India where the singer laments, "The Tamarind I planted in my youth is full of life, but there is none in me". Some tribes in Maharashtra worship the tamarind as a totem (*devak*) and believe that sleeping under it is injurious to health.

Almost every part of the tamarind finds some use. The pulp of the ripe pod is sour in taste owing to the presence of tartaric, malic and citric acids, and is used as a souring agent for sauces and foods; the unripe pods make a fine tangy *chutney* when grated and blended. One variety of tamarind is also known where the pulp is acid sweet. The pulp, separated from the fibre, is often processed for culinary use, though the salted crude pulp is preferred by the majority. The pulp is also a purgative by virtue of its tartaric acid content. The Burmese make an excellent sherbet, called *phyaw-ye*, by mixing the pulp with gur (jaggery) and water and cooling it. And, then, every housewife knows that tamarind pulp is a good polish for copper and brassware.

The seed kernel, which contains 17 per cent protein, is sometimes ground and consumed by tribal folk. Tamarind kernel powder, known in commercial circles as TKP, is rich in a polysaccharide, jellose, which imparts a peculiar property to it which makes it useful in a variety of ways: the powder, when boiled and dried in layers, produces elastic sheets. This powder is, therefore, used for stabilising jams, jellies, icecreams, jujubes, cosmetics, printing pastes, etc. Huge consignments are exported to the West for this purpose. In fact, India is the largest producer of tamarind products. Tender leaves

The lowest branch of this neem tree at Shoigaon in Maharashtra is said to be sprouting *sweet* leaves since, legend says, the branch had hit the head of the Raja of Kadoba passing below

Karanj

Mali

and flowers of the tamarind are edible and used as vegetables. The heartwood is extremely strong and durable and is a prized timber for making durable implements.

Perhaps, one reason for the tamarind's durability is the fact that it is drought-resistant and can withstand the full blast of the monsoon as well. Its dual-root system comprising a superficial and a deep one allows the tree to survive under difficult conditions. The superficial roots, ramifying close to the topsoil, permit competition with grasses for nutrients from the soil, while the deep roots plunge deep down into the soil to tap ground

Java plum (jamun)

Mali

water under drought conditions. Taken together, this means that such a root system prevents soil erosion. Dr. M. S. Randhawa recommends that tamarind trees along with other hardy trees, like the neem, should be planted on wastelands with degraded soil as a measure of conservation and as an exploitable resource.

A tree of singular beauty grown near temples — especially Buddhist places of worship — is the **ashoka** (*Saraca asoca*). The ashoka tree is a medium-sized evergreen tree, indigenous to India, Burma and Malaysia. It is found all over our country, both in the wild state and in cultivated groves called *vans*. (Each *van* may consist predominantly of one species of tree, in which case it is prefixed by the name of that particular tree, as for example, in this case, the grove would be called *ashokvan*.) Ashoka groves were carefully tended and maintained by ancient Buddhist monks who were inspired 20 centuries ago to carve works of art into living rock. The ashoka grows along streams and in evergreen forests of the west coast of India, the Khasi, Garo and Lushai hills, and also in the Andaman islands. The compact canopy of dark green leaves crown the trunk which has a smooth, dull grey or brown bark; in older trees, however, the bark becomes black, with a rough, warty surface.

The compound leaf is about 30 cm long and bears four to six pairs of long leaflets. By the end of the cold season new leaves emerge, light red to delicate mauve at first, but turning dark green as they mature. The drooping young leaves hanging like red silken tassels from the ends of branches present an unusual and interesting sight, particularly when back-lighted.

The ashoka flowers throughout the year in some locales, but January and February are the best months to witness its flowering glory. The fragrant flowers occur in dense clusters all over the tree, yellow to yellowish-orange at first, then changing colour to a bright vermilion. The corolla is tubular and opens out into four small lobes; the many long stamens that emerge from each tube give a hairy appearance to the flower cluster. The general aspect during flowering

Ashoka

Mali

Temple tree flower

Mali

s one of scores of fiery red embers glowing on the tree; probably, this spectacular flowering of the ashoka inspired and perpetuated the popular belief that the tree would flower only when kicked by the left foot of a pretty maiden (as Kalidasa has described in his play *Malavikagnimitram*)! The *Ramayana* describes the sojourn of Sita in an *ashokvan* after her abduction by Ravana. The tree has also been represented in sculpture: a bracket and railing pillar discovered at an ancient site at Kankali Tila near Mathura belonging to the reign of Kanishka depicts a woman under an ashoka tree (see p. 34). Buddhists venerate it because Gautama Buddha is believed to have been born under an ashoka tree.

The ashoka tree has been found to possess medicinal qualities: bark extracts, which contain a glycoside (the active principle), stimulate many tissues, notably the uterus. For this reason it is used in uterine disorders; in fact, the Indian Pharmaceutical Codex officially recognises two liquid preparations made from the ashoka.

The long, flat, four to eight-seeded dark pods are chewed in Assam (instead of arecanuts); they are also fed to livestock. The wood of the ashoka is light, soft and reddish-brown, and is used for implements and building purposes.

Kilometre upon endless kilometre the dry plains of the Deccan plateau stretch out towards the horizon in a continuous monotony. As one travels from one village or town to the next, the regularity of the treeless cultivated fields of black cotton soil (where undoubtedly good forests flourished in bygone days) is broken, off and on, by patches of trees that have been spared the villagers' axe. A prominent tree in these sparse manifestations of verdure is the **neem** or **margosa** tree (*Azadirachta indica*).

Though familiar to the village folk and the interested urbanite, it can be easily overlooked as it lacks showy or flamboyant flowers and has only a few medicinal uses. However, the neem tree which is indigenous to our land has been known since ages; it has been mentioned by Valmiki (it's called *nimba* in Sanskrit) among the large number of trees encountered by Rama during his travels.

The neem is a medium-sized evergreen tree which may reach to a height of about 8 to 10 metres. In the drier regions, where it thrives well in the black cotton soil, it tends to be deciduous. The bark is thick and may be heavily fissured; it is dark grey on the outside and reddish on the inside. The leaves are very distinctive; each leaf is pinnate and has an odd number of leaflets. The leaflet, too, is characteristic — it has a serrated (toothed) margin and is curved with one half of the leaf larger than the other, giving the appearance of a scythe.

Flowers appear between March and May every year in large numbers, scores of which are borne on long slender stems arising from the axils (angles) of the leaves. Each flower has five sepals and five petals and bears one fruit. The flowers attract large gatherings of bees and other insects. The fruit is about two to three cm long, oblong, green when raw but yellow on ripening from June to August. The single seed it contains is surrounded by a very bitter pulp; in fact, all parts of the tree are bitter including the heartwood which resists attack by insects and termites.

The tree figures in Indian folklore; some tribes of Maharashtra worship the neem tree, too, as a totem. Unlike the tamarind, the neem tree is considered health-giving. On the Hindu New Year's day, the bitter

Mali

Mohwa

leaves are eaten with sugar to ward off illness. The tree has also inspired some folk songs. An Avadhi song from North India glorifies the tree: in the opening stanza a daughter implores her father not to cut down the neem tree as it offers a roosting place for sparrows; this song is called *hindole-ka-geet* (song of the swing). A Kannada song from South India extols the neem's cool shade.

The leaves possess an insecticidal action, and dried leaves are kept with clothing, books, grains, etc to keep away insects. The pulp of the fruit, though bitter, is eaten by monkeys. The seed oil (margosa oil) is acrid, bitter, yellow and has a disagreeable odour. It is used in the indigenous system of medicine for treating skin diseases and rheumatism, and as a vermifuge. The bitter, active substance present in the plant is a chemical known as nimbidin. The oil has been used for manufacture of medicated soap. Twigs of the neem serve as rustic toothbrushes. The

Mali

Neem

Tamarind

Alu

Mali

reddish brown, termite-resistant heartwood is used for construction of houses, boats, ploughs, toys, etc, and is said to resemble mahogany in beauty and hardness. Incidentally, the Latin name of neem was adopted from *Azadirachta*, the Persian name of another tree (*Melia azaderach*) which superficially resembles the neem and belongs to the same family (Meliaceae).

An important tree yielding excellent edible fruit, good timber and medicinal ingredients is the well-known **jamun** (*Syzygium cuminii*). This evergreen tree which attains a moderate to large size is found throughout India in both the wild state and under cultivation in orchards. The jamun, also sometimes called the Java plum or black plum, when planted and tended has a straight trunk with greyish-brown rough bark, but in its natural habitat the tree becomes knotted and stunted, and is often festooned with mosses growing on its branches, especially in the wet rain forests. Sometimes it is planted on the roadside as an avenue tree or as a windbreak.

The leaves, about 9 to 10 cm long, are single and entire, arising on opposite sides of a central stem. They have a rather strong though not unpleasant aromatic odour when crushed. The flowers which bloom from March to May are small and occur in aggregations on stems below the leaves; thus, they may not be noticed by the casual observer. The whitish calyx and corolla are single and not divided as in other plants; the cup-like corolla falls off and exposes the numerous hair-like stamens — which just seem to burst out of the calyx.

Jamun tree

Woman under a tree: **sculpture from the Kushan period (Mathura Museum)**

Fruiting occurs from June to August and often a tree is heavy with the purplish-black, smooth-skinned, glossy fruits each of which may be two to four cm long and oblong with one seed embedded in purple-red pulp. The delicate fruits often fall off in a stiff wind and litter the ground, attracting blue-bottle flies, butterflies, and in forests, perhaps an occasional jackal or civet.

Several types of jamun are recognised by the different colours and sizes of the fruits. Two varieties usually encountered are: the big-sized *rajamun* with a small seed and sweet voluminous pulp, and the *katha* variety with small fruit and acidic pulp. The jamun grows well in widely differing localities but thrives where the soil is damp, like the banks of streams; the *ra-jamun* is particularly hardy and resists waterlogging. The jamun coppices well, that is, when the main trunk is felled, new shoots develop from the lower portion and grow to tree proportions. Propagation is by seeds and a tree starts yielding fruit in eight to 10 years and continues to do so for about 70 years. The leaves are fed on by caterpillars of numerous moth species; on some trees one may find the ingenious leaf nests of the large vicious red ants, *Oecophylla smaragdina*, much to the dismay of young boys who climb them for their fruits.

The jamun is mentioned in the works of Valmiki and Kalidasa; the Hindus consider the tree to have a sacred association with Lord Krishna.

Most parts of the jamun tree are useful. The fruit is edible though some individuals may not like its astringent taste. Some improved varieties have been developed which are seedless and more palatable. The pulp is rich in glucose and fructose and is made into preserves, squashes and even a liquor. The flowers are a source of honey, especially of the big rock bees (*Apis dorsata*) of the Western Ghats.

Despite the strong aroma, jamun leaves are a good source of protein (9 per cent) for livestock; they also serve as green manure, and as feed for the larvae of the *tussar* silk moth. The seeds are rich in protein and calcium and serve as feed for livestock.

In the Indian systems of medicine, the jamun has been used for treating diarrhoea, dysentery and diabetes. Recently, the dried alcoholic extract of jamun seeds has been found to reduce the blood sugar level of diabetic patients. Jamun timber is reddish-grey to brown in colour; being rather durable under water, it finds application in boat-building, fashioning oars and agricultural implements, tool handles and cart wheels.

The **mohwa** or **Indian butter tree** is a medium-to-large deciduous tree with large elliptical, entire leaves found all over the Indian plains and forests. It is known as *madhuka* in Sanskrit from which the botanical name *Madhuca indica* has been adapted. Between February and April, the leaves fall off and bunches of flowers appear at the ends of the spreading crown. Each flower, which is borne on a furry brown stalk, has a tubular, thick, white fleshy corolla which has a sickly sweet odour and taste. The generous yield

Mohwa tree

of its edible flowers is what makes the mohwa an economically important tree. Tribal folk have for centuries gathered and consumed its fleshy flowers which can also be dried and preserved. New leaves appear just about the time the tree flowers and are initially reddish-brown turning dark green later. The oval fruit is about five cm long, light brown in colour and usually contains one seed. The oil extracted from mohwa seeds has been used by tribals as a cooking oil. In cold weather, it solidifies to a buttery consistency and is sometimes used as an adulterant of ghee. The oil is also used for making laundry soap, candles, as a lubricant and a raw material for stearic acid. The oil acts as an emollient in skin diseases, and is also a laxative. The cake left over after extraction of the oil is unfit as an animal feed because it contains a toxic principle (saponin) called mowrin; it finds use however as a manure, and is applied to lawns and golf courses because of its insecticidal properties. In South India, the residue is employed as a hairwash mixed with the soapnut pulp. The dried flowers are rich in sugar, calcium and vitamins; they are eaten either raw or cooked, but vomiting and light-headedness may occur if a large quantity is consumed. A very strong and heady liquor can be prepared from the flowers. Some tribals worship the mohwa tree during marriage rites: the bride smears it with vermilion and embraces it.

The **karanj** or **pongam** (*Pongamia pinnata*) is a fairly large tree found growing throughout India along stream banks and tidal forests. This deciduous tree belongs to the pea family and is widely distributed in South-East Asia and even up to Australia; it is also popular as a roadside tree in some of our cities. Between February and April, the leaves are shed and new leaves grow; the tree then bursts into bloom and entire trees are seen to be decked with the small pale-pink or mauve flowers many of which fall off and carpet the ground below. The single-seeded flat pods develop in May and June, and in some places in November and December.

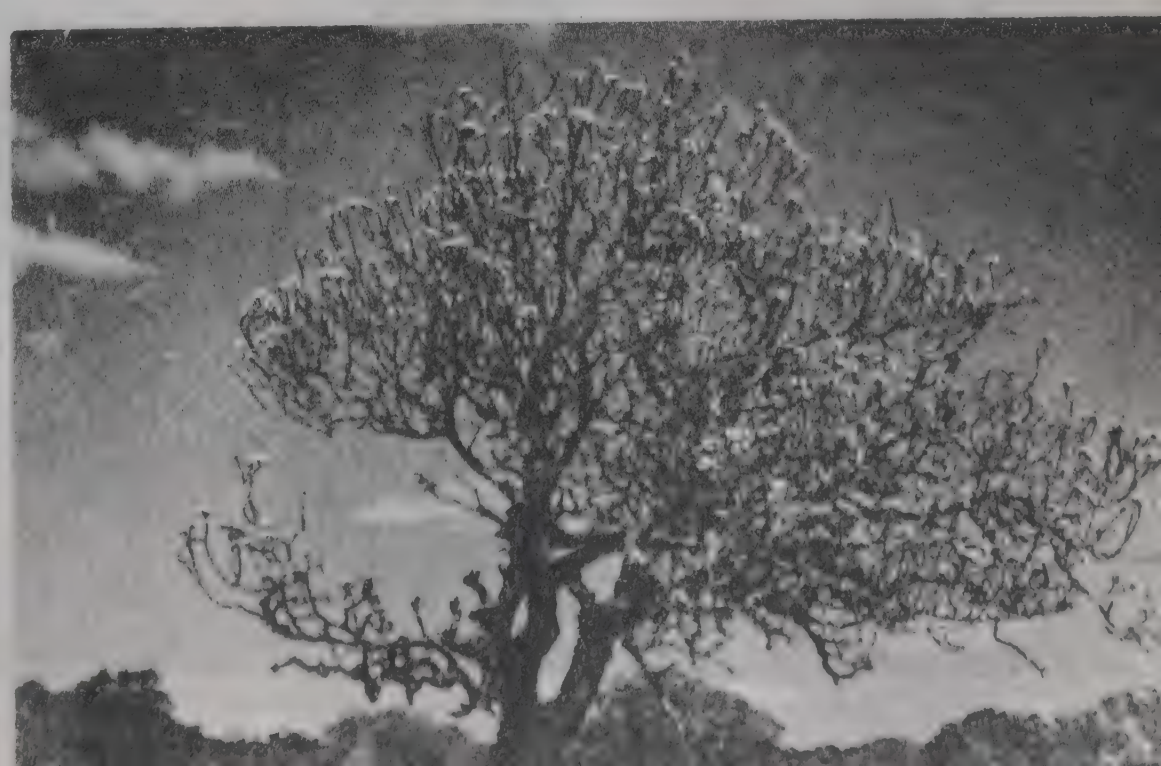
The karanj is a fast-growing tree which also coppices well. It is a host to the lac insect. The oil extracted from the seeds has a disagreeable odour and is used as an illuminant, for dressing leather, soap-making and as a lubricant. It has been used to treat skin diseases like scabies and leucoderma in indigenous medicine. The active substances present in the oil are two bitter flavones, karanjin and pongamol. The seed cake is not fit for livestock but is used in sugarcane fields and gardens as it repels red ants and is also good as manure. Local people make cordage from the stem bark, and feed the leaves to their domestic stock; an infusion of karanj leaves is a native lotion for cleansing sores and ulcers. For afforestation, especially of watersheds in the drier regions, the karanj has been recommended.

In 1841, a handsome flowering tree of the dogbane family (*Apocynaceae*) was introduced into India from the Philippines. This tree, variously known as the **pagoda tree, temple tree,** or **dead man's flower** is *Plumeria rubra* which is named in honour of the 17th century French botanist, Charles Plumier. It is a native of Mexico and Guatemala and like most exotics flourishes on our soil where it is planted near temples, over graves and generally in some gardens and parks. There are about eight species of *Plumeria* in India but there is some confusion concerning their nomenclature since there is a good deal of overlap of their features and some may in fact be hybrids. The tree flowers all the year round. The large, fragrant, white or pink flowers have five petals which are tinted with yellow at the base on the inside. A red form of the tree (the frangipani) is also sometimes grown. The leaves are long and narrow. All parts of the tree exude a milky latex; the Sanskrit name *kshira champa* (milky champa) refers to this characteristic. The latex has been used in native medicine as a counter-irritant in rheumatism, as a purgative and as an ointment for itches and bleeding gums. The flowers are threaded together to make garlands, and in some places the leaves are tied to the trunks of coconut palms to protect them from infestation by the long-horned beetle. The pagoda tree is very popular for its sweet-smelling flowers and the ease with which it can be grown from cuttings.

A rather unusual tree for a townsman, who may only occasionally see a few of its fruits for sale in bazaars, but is a treat for the young in rustic India is the **alu** (*Meyna laxiflora*). A small tree with opposite leaves and sharp spines, the alu yields every year a small number of brown, pulpy edible fruits the size of a table-tennis ball. The fruit ripens in May and June, and has a sour-sweet metallic taste which one has to learn to like. The nutritive value of the fruit has not been analysed though it is common enough in the Konkan and the Western Ghats. The leaves are eaten as a vegetable and used as a fodder for livestock.

The alarming rate at which our village flora is vanishing is indeed sad. Instead of lamenting, should we not replenish what is lost by planting our own indigenous trees?

S. R. AMLADI



Pagoda tree in bloom

The dominant model of disease today is biomedical, and it leaves no room within its framework for the social and psychological dimensions of illness

the need for a new medical model

GEORGE L. ENGEL

At a recent conference on psychiatric education, many psychiatrists seemed to be saying to medicine, " Please take us back and we will never again deviate from the ' medical model '." For, as one critical psychiatrist put it, " Psychiatry has become a hodgepodge of unscientific opinions, assorted philosophies and ' schools of thought ', mixed metaphores, role diffusion, propaganda, and politicking for ' mental health ' and other esoteric goals." In contrast, the rest of medicine appears neat and tidy. It has a firm base in the biological sciences, enormous technologic resources at its command, and a record of astonishing achievement elucidating mechanisms of disease and devising new treatments. It would seem that psychiatry would do well to emulate its sister medical disciplines by finally embracing once and for all the medical model of disease.

But I do not accept such a premise. Rather, I contend that all medicine is in crisis and, further, that medicine's crisis derives from the same basic fault as psychiatry's, namely, adherence to a model of disease no longer adequate for the scientific tasks and social responsibilities of either medicine or psychiatry.

Psychiatry's crisis revolves around the question of whether the categories of human distress with which it is concerned are properly considered

Illustrated by Sushma

disease " as currently conceptualed.

Medicine's crisis stems from the gical inference that since " disease " defined in terms of somatic paraeters, physicians need not be conrned with psychosocial issues which outside medicine's responsibility nd authority. At a recent Rockefeller oundation seminar on the concept health, one authority urged that edicine " concentrate on the ' real ' seases and not get lost in the psychociological underbrush. The physian should not be saddled with proems that have arisen from the abdiation of the theologian and the hilosopher ".

Psychiatrists have responded to eir crisis by embracing two ostenbly opposite positions. One would mply exclude psychiatry from the eld of medicine, while the other ould adhere strictly to the " medical odel " and limit psychiatry's field behavioural disorders consequent brain dysfunction. The first is exemlified in the writings of Szasz and thers who advance the position that mental illness is a myth " since it oes not conform with the accepted oncept of disease. [T. S. Szasz, *The Myth of Mental Illness* (1961); E. F. Torrey, *The Death of Psychiatry* (1974).] upporters of this position advocate he removal of the functions now perormed by psychiatry from the conceptual and professional jurisdiction f medicine and their reallocation to new discipline based on behavioural cience. Henceforth medicine would e responsible for the treatment and ure of disease, while the new discipline would be concerned with the reducation of people with " problems f living ". Disorders directly ascribble to brain disorder would be taken are of by neurologists, while psychiary as such would disappear as a nedical discipline.

In sum, psychiatry struggles to clarify its status within the mainstream of medicine, if indeed it belongs in medicine at all. The criterion by which this question is supposed to be resolved rests on the degree to which the field of activity of psychiatry is deemed congruent with the existing medical model of disease. But crucial to this problem is another, that of whether the contemporary model is, in fact, any longer adequate for medicine, much less for psychiatry. For, if it is not, then perhaps the crisis of psychiatry is part and parcel of a larger crisis that has its roots in the model itself.

The biomedical model

The dominant model of disease today is biomedical, with molecular biology its basic scientific discipline. It assumes disease to be fully accounted for by deviations from the norm of measurable biological (somatic) variables. It leaves no room within its framework for the social, psychological and behavioural dimensions of illness. The biomedical model not only requires that disease be dealt with as an entity independent of social behaviour, it also demands that behavioural aberrations be explained on the basis of disordered somatic (biochemical or neurophysiological) processes. Thus, the biomedical model embraces both reductionism, the philosophic view that complex phenomena are ultimately derived from a single primary principle, and mind-body dualism, the doctrine that separates the mental from the somatic.

The biomedical model was devised by medical scientists for the study of disease. As such it was a scientific model; that is, it involved a shared set of assumptions and rules of conduct based on the scientific method and constituted a blueprint for research. As H. Fabrega has pointed out, " disease " in its generic sense is a linguistic term used to refer to a certain class of phenomena that members of all social groups, at all times in the history of man, have been exposed to. " When people of various intellectual and cultural persuasions use terms analogous to ' disease,' they have in mind, among other things, that the phenomena in question involve a person-centred, harmful, and undesirable deviation or discontinuity . . . associated with impairment or discomfort." Since the condition is not desired, it gives rise to a need for corrective actions. The latter involve beliefs and explanations about disease as well as rules of conduct to rationalise treatment actions.

Such culturally derived belief systems about disease also constitute models, but they are not scientific models. These may be referred to as popular or folk models. As efforts at social adaptation, they contrast with scientific models, which are primarily designed to promote scientific investigation. The historical fact we have to face is that in modern Western society, biomedicine not only has provided a basis for the scientific study of disease, it has also become our own culturally specific perspective about disease, that, is, our folk model.

In our culture, the attitudes and belief systems of physicians are moulded by this model long before they embark on their professional education, which in turn reinforces it without necessarily clarifying how its use for social adaptation contrasts with its use for scientific research. The biomedical model has thus become a cultural imperative, its limitations easily overlooked. In brief, it has now acquired the status of *dogma*. In science, a model is revised or abandoned when it fails to account adequately for all the data. A dogma, on the other hand, requires that discrepant data be forced to fit the model or be excluded. Biomedical dogma requires that all disease, including " mental " disease, be conceptualised in terms of derangement of underlying physical mechanisms. This permits only two alternatives

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whereby behaviour and disease can be reconciled: the reductionist, which says that all behavioural phenomena of disease must be conceptualised in terms of physicochemical principles; and the exclusionist, which says that whatever is not capable of being so explained must be excluded from the category of disease.

The reductionists concede that some disturbances in behaviour belong in the spectrum of disease. They categorise these as mental diseases and designate psychiatry as the relevant medical discipline. The exclusionists regard mental illness as a myth and would eliminate psychiatry from medicine. Among physicians and psychiatrists today the reductionists are the true believers, the exclusionists are the apostates, while both condemn as heretics those who dare to question the ultimate truth of the biomedical model and advocate a more useful model.

In all societies, ancient and modern, preliterate and literate, the major criteria for identification of disease have always been behavioural, psychological and social in nature. Classically, the onset of disease is marked by changes in physical appearance that frighten, puzzle, or awe, and by alterations in functioning, in feelings, in performance, in behaviour, or in relationships that are experienced or perceived as threatening, harmful, unpleasant, deviant, undesirable, or unwanted. Reported verbally or demonstrated by the sufferer or by a witness, these constitute the primary data upon which are based first-order judgments as to whether or not a person is sick. To such disturbing behaviour and reports all societies typically respond by designating individuals and evolving social institutions whose primary function is to evaluate, interpret, and provide corrective measures. Medicine as an institution and as a discipline, and physicians as professionals, evolved as one form of response to such social needs. In the course of history, medicine became scientific as physicians and other scientists developed a taxonomy and applied scientific methods to the understanding, treatment and prevention of disturbances which the public first had designated as "disease" or "sickness".

Why did the reductionistic, dualistic biomedical model evolve in the West? H. Rasmussen identifies one source in the concession of established Christian orthodoxy to permit dissection of the human body some five centuries ago. Such a concession was in keeping with the Christian view of the body as a weak and imperfect vessel for the transfer of the soul from this world to the next. Not surprisingly, the Church's permission to study the human body included a tacit interdiction against corresponding scientific investigation of man's mind and behaviour. For, in the eyes of the Church these had more to do with religion and the soul and hence properly remained its domain.

This compact may be considered largely responsible for the anatomical and structural base upon which scientific Western medicine eventually was to be built. For, at the same time, the basic principle of the science of the day, as enunciated by Galileo, Newton and Descartes, was analytical, meaning that entities to be investigated be resolved into isolable causal chains or units, from which it was assumed that the whole could be understood, both materially and conceptually, by reconstituting the parts. With mind-body dualism firmly established under the imprimatur of the Church, classical science readily fostered the notion of the body as a machine, of disease as the consequence of breakdown of the machine, and of the doctor's task as repair of the machine. Thus, the scientific approach to disease began by focusing in a fractional-analytic way to biological (somatic) processes and ignoring the behavioural and psychosocial. This was so even though in practice many physicians, at least until the beginning of the 20th century, regarded emotions as important for the development and course of disease.

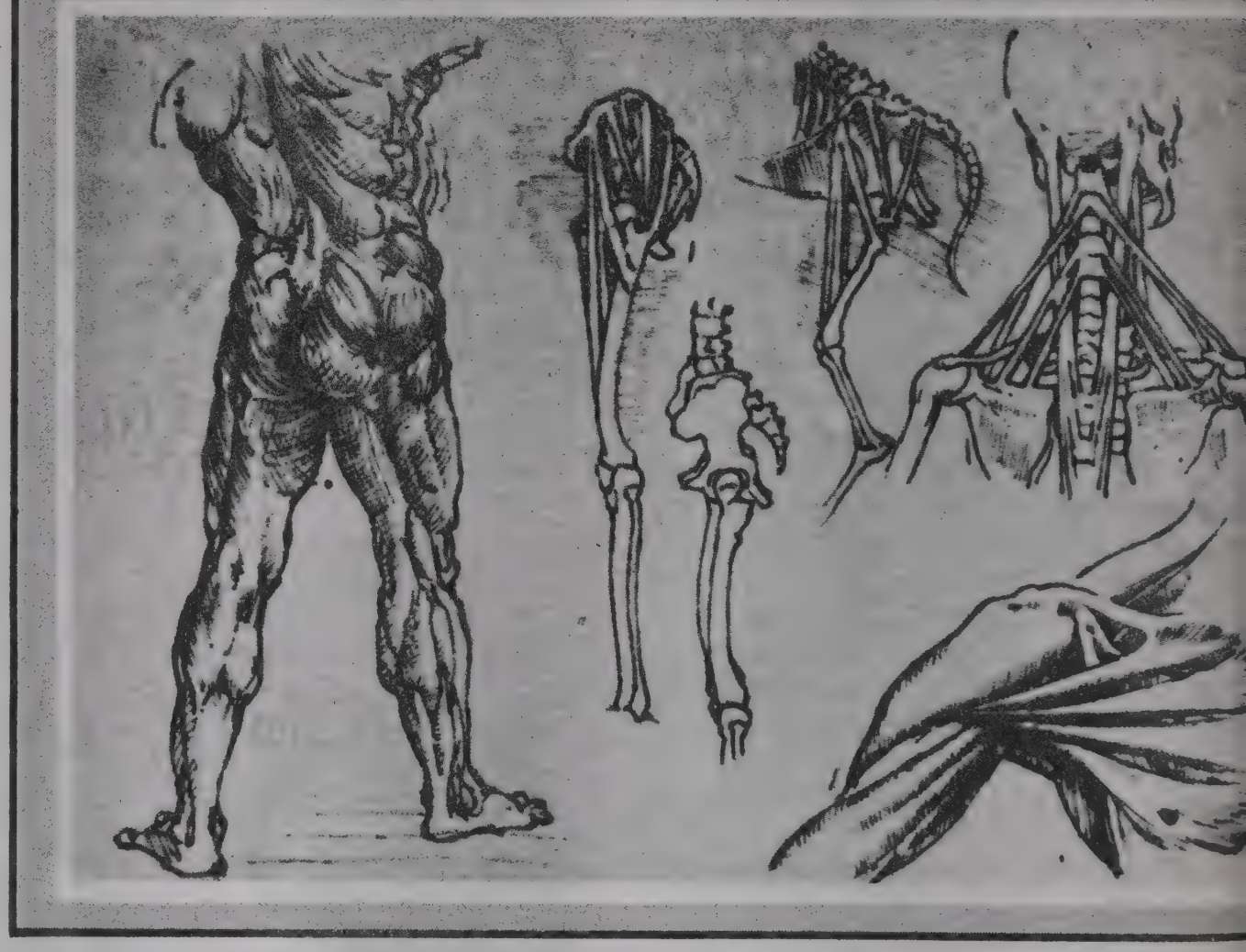
Limitations of the biomedical model

We are now faced with the necessity and the challenge to broaden the approach to disease to include the psychosocial without sacrificing the enormous advantages of the biomedical approach. In a recent critique of the exclusionist position, Kety put the contrast between the two in such a way as to help define the issues: "According to the medical model, a human illness does not become a specific disease all at once and is not equivalent to it. The medical model of an illness is a process that moves from the recognition and palliation of symptoms to the characterisation of a specific disease in which the etiology and pathogenesis are known and treatment is rational and specific." [S. Kety, *Am. J. Psychiatry*, **131,** 957 (1974).] Thus, taxonomy progresses from symptoms, to clusters of symptoms, to syndromes, and finally to diseases with specific pathogenesis and pathology. This sequence accurately

Art and Anatomy

"Anatomy showed the first stirrings of a new life at the beginning of the fourteenth century, when the first records of original human dissections begin to appear. In 1316, Mondinus published his *Anathomia*, which nudged the subject out of the Arabian twilight. . . . It was not, however, until the middle of the century that the practice of dissection received official sanction.

"Medical students were not the only individuals of the Italian quattrocento interested in anatomy. An avid interest was also shown by the painters and sculptors. It has been suggested that



describes the successful application of the scientific method to the elucidation and the classification into discrete entities of disease in its generic sense.

Kety approaches this problem by comparing diabetes mellitus and schizophrenia as paradigms of somatic and mental diseases, pointing out the appropriateness of the medical model for both. " Both are symptom clusters or syndromes, one described by somatic and biochemical abnormalities, the other by psychological. Each may have many etiologies and shows a range of intensity from severe and debilitating to latent or borderline. There is also evidence that genetic and environmental influences operate in the development of both."

of patients with diabetes, a " somatic disease", and with schizophrenia, a " mental disease ", in exactly the same terms, we will see more clearly how inclusion of somatic and psychosocial factors is indispensable for both; or more pointedly, how concentration on the biomedical and exclusion of the psychosocial distorts perspectives and even interferes with patient care.

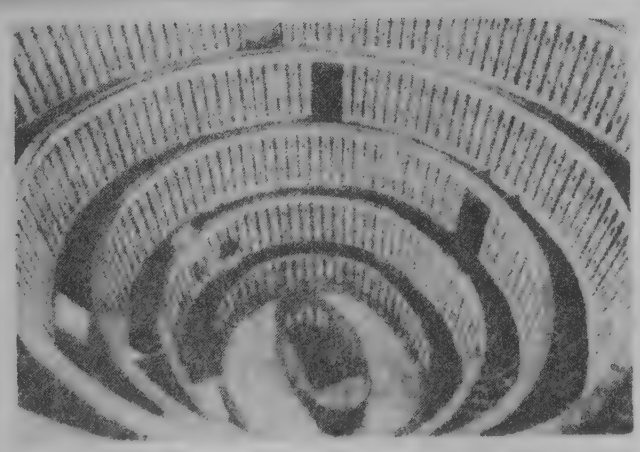
(1) In the biomedical model, demonstration of the specific biochemical deviation is generally regarded as a specific diagnostic criterion for the disease. Yet, in terms of the human experience of illness, laboratory documentation may only indicate disease potential, not the actuality of the disease at the time. The abnormality may be present, yet the patient not be

the initial point of contact between these otherwise two disparate groups was the apothecary's shop. Here the physician would come for his specifics and the artist for his pigments. The interest of the artist in surface anatomy would lead him to accompany his new acquaintance to the still rather infrequent public anatomies. Later, in their ardent pursuit of naturalism, the artists themselves began to make dissections. So far as is known, the earliest instance of an eminent artist-anatomist is Donatello (1386-1466). . . .

" Perhaps too much should not be made of this conjunction of anatomists and artists. For, with the gigantic exception of Leonardo himself, the painters, almost by definition, were interested only in superficial anatomy. With Leonardo, however, we meet an altogether different phenomenon. . . . He was not content merely to record what he saw, but sought always to go further and attempt to understand how the body functioned. Indeed, so enthusiastic an engineer as Leonardo could hardly escape treating the body as a divine machine. In drawing after drawing after drawing we see him endeavouring to show with his crayon how part acted upon part, how muscle acted on bone, how bone articulated with bone. . . .

" Leonardo's work, however, was not published during his lifetime nor for centuries thereafter. Although it was known to exist, it seems to have had little or no influence on the subsequent history of anatomy. . . . Anatomists consequently followed their own plodding paths. Leonardo, the eagle, remained largely unknown and the tradition from Mondinus passed through Berengaria da Capri (c. 1460-1530) to the young Andreas Vesalius (1514-1564)."

— C.U.M. Smith (*The Problem of Life*, 1976)



(Left) A page from Leonardo's anatomical drawings. (Right) The first permanent anatomy theatre was completed in Padua in Italy in 1594, 75 years after Leonardo's death

Requirements of a new medical model

To explore the requirements of a medical model that would account for the reality of diabetes and schizophrenia as human experiences as well as disease abstractions, let us expand Kety's analogy by making the assumption that a specific biochemical abnormality capable of being influenced pharmacologically exists in schizophrenia as well as in diabetes — certainly a plausible possibility. By obliging ourselves to think

ill. Thus, the presence of the biochemical defect of diabetes or schizophrenia at best defines a necessary but not a sufficient condition for the occurrence of the human experience of the disease — the illness. Thus, while the diagnosis of diabetes is first suggested by certain core clinical manifestations, for example, polyuria, polydipsia, polyphagia, and weight loss, and is then confirmed by laboratory documentation of relative insulin deficiency, how these are experienced and how they are reported by any one individual, and how they affect him,

all require consideration of psychological, social and cultural factors, not to mention other concurrent or complicating biological factors.

(2) Establishing a relationship between particular biochemical processes and the clinical data of illness requires a scientifically rational approach to behavioural and psychosocial data, for these are the terms in which most clinical phenomena are reported by patients. Many verbal expressions derive from bodily experiences early in life, resulting in a significant degree of ambiguity in the language patients use to report symptoms. Hence the same words may serve to express psychological as well as bodily disturbances, both of which may coexist and overlap in complex ways. Thus, virtually each of the symptoms classically associated with diabetes may also be expressions of or reactions to psychological distress, just as ketoacidosis and hypoglycemia may induce psychiatric manifestations, including some considered characteristic of schizophrenia. The most essential skills of the physician involve the ability to elicit accurately and then analyse correctly the patient's verbal account of his illness experience. The biomedical model ignores both the rigour required to achieve reliability in the interview process and the necessity to analyse the meaning of the patient's report in psychological, social, and cultural, as well as in anatomical, physiological or biochemical terms.

(3) Diabetes and schizophrenia have in common the fact that psychophysiologic responses to life change may interact with existing somatic factors to alter susceptibility and thereby influence the time of onset, the severity, and the course of a disease.

(4) Psychological and social factors are also crucial in determining whether and when patients with the biochemical abnormality of diabetes or of schizophrenia come to view themselves or be viewed by others as sick. Still other factors of a similar nature influence whether or not and when any individual enters a health care system and becomes a patient. Thus, the biochemical defect may determine certain characteristics of the disease, but not necessarily the point in time when the person falls ill or accepts the sick role or the status of a patient.

(5) " Rational treatment " (Kety's term) directed only at the biochemical abnormality does not necessarily restore the patient to health even in the face of documented correction or major alleviation of the abnormality. This is no less true for diabetes than it will be for schizophrenia when

a biochemical defect is established. Other factors may combine to sustain patienthood even in the face of biochemical recovery.

(6) Even with the application of rational therapies, the behaviour of the physician and the relationship between patient and physician powerfully influence therapeutic outcome for better or for worse. These constitute psychological effects which may directly modify the illness experience or indirectly affect underlying biochemical processes. Thus, insulin requirements of a diabetic patient may fluctuate significantly depending on how the patient perceives his relationship with his doctor. Furthermore, the successful application of rational therapies is limited by the physician's ability to influence and modify the patient's behaviour in directions concordant with health needs. Contrary to what the exclusionists would have us believe, the physician's role is, and always has been, very much that of educator and psychotherapist.

The boundaries between health and disease, between well and sick, are far from clear and never will be clear, for they are diffused by cultural, social and psychological considerations. The traditional biomedical view, that biological indices are the ultimate criteria defining disease, leads to the present paradox that some people with positive laboratory findings are told that they are in need of treatment when in fact they are feeling quite well, while others feeling sick are assured that they are well, that is, they have no " disease ". A biopsychosocial model which includes the patient as well as the illness would make it possible to explain why some individuals experience as " illness " conditions which others regard merely as " problems of living ", be they emotional reactions to life circumstances or somatic symptoms. Indeed, some people deny the unwelcome reality of illness by dismissing as " a problem of living " symptoms which may in actuality be indicative of a serious organic process. It is the doctor's, not the patient's, responsibility to establish the nature of the problem and to decide whether or not it is best handled in a medical framework.

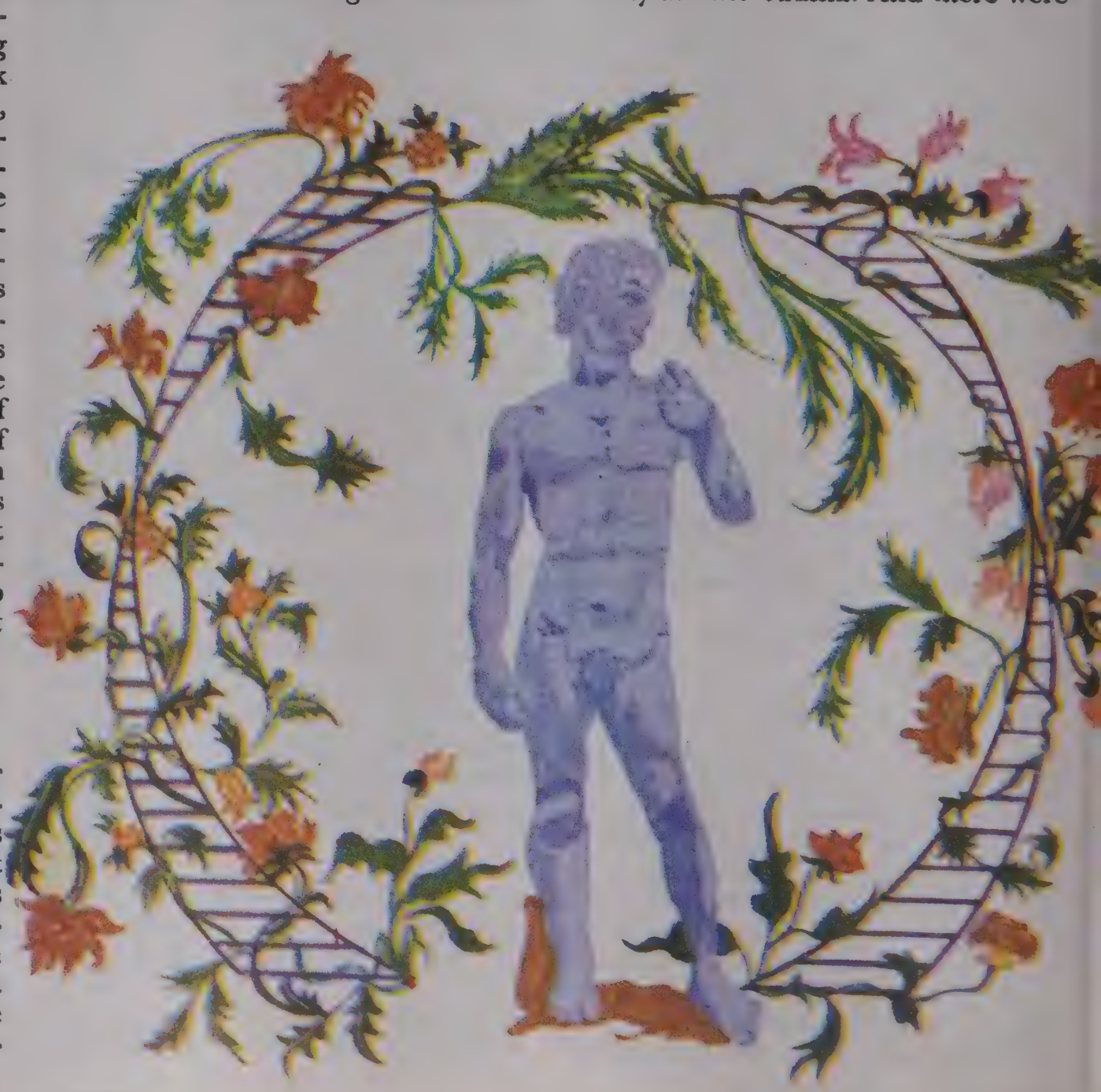
When is grief a disease?

To enhance our understanding of how it is that " problems of living " are experienced as illness by some and not by others, it might be helpful to consider grief as a paradigm of such a borderline condition. For while grief has never been considered in a medical framework, a significant number of grieving people do consult doctors because of disturbing symptoms, which they do not necessarily relate to grief. Fifteen years ago, I addressed this question in a paper entitled " Is grief a disease? A challenge for medical research ". Its aim, too, was to raise questions about the adequacy of the biomedical model. A better title might have been, " When is grief a disease? ", just as one might ask when schizophrenia or when diabetes is a disease? For while there are some obvious analogies between grief and disease, there are also some important differences.

Grief clearly exemplifies a situation in which psychological factors are primary; no pre-existing chemical or physiological defects or agents need be invoked. Yet, as with classic diseases, ordinary grief constitutes a discrete syndrome with a relatively predictable symptomatology which includes, incidentally, both bodily and psychological disturbances. It displays the autonomy typical of disease; that is, it runs its course despite the sufferer's efforts or wish to bring it to a close.

On the face of it, the arguments against including grief in a medical model would seem to be the more persuasive. In the 1961 paper, I countered these by comparing grief to a wound. Both are natural responses to environmental trauma, one psychological, the other physical. But even at the time I felt a vague uneasiness that this analogy did not quite make the case. Now 16 years later a better grasp of the cultural origins of disease concepts and medical care systems clarifies the apparent inconsistency. The critical factor underlying man's need to develop folk models of disease, and to develop social adaptations to deal with the individual and group disruptions brought about by disease, has always been the victim's ignorance of what is responsible for his dysphoric disturbing experience. Neither grief nor a wound fits fully into that category. In both, the reasons for the pain, suffering and disability are only too clear.

Wounds or fractures incurred in battle or by accident by and large were self-treated or ministered to with folk remedies or by individuals who had acquired certain technical skills in such matters. Surgery developed out of the need for treatment of wounds and injuries and has different historical roots than medicine, which was always closer in origin to magic and religion. Only later in Western history did surgery and medicine merge as healing arts. But even from earliest times there were people who behaved as though grief-stricken, yet seemed not to have suffered any loss; and others who developed what for all the world looked like wounds or fractures, yet had not been subjected to any known trauma. And there were



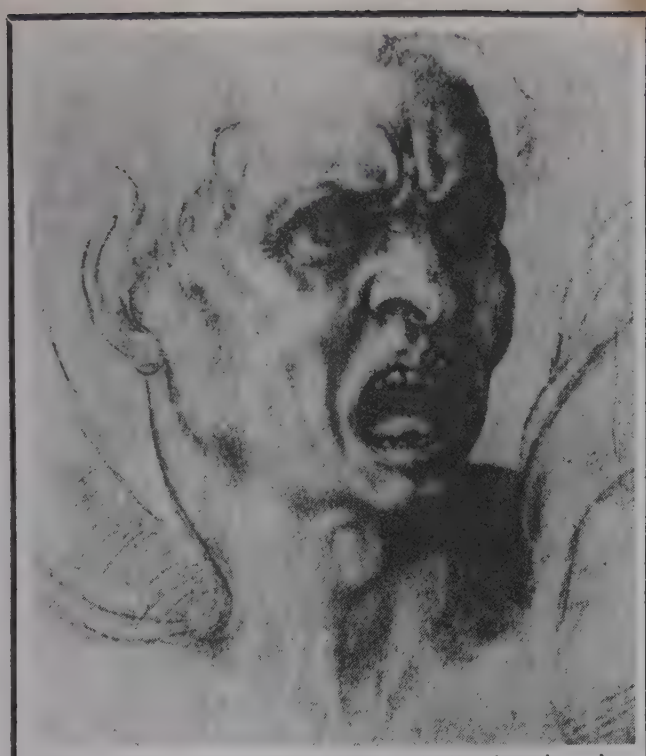
Sushma

people who suffered losses whose grief deviated in one way or another from what the culture had come to accept as the normal course; and others whose wounds failed to heal or festered or who became ill even though the wound had apparently healed. Then, as now, two elements were crucial in defining the role of patient and physician and hence in determining what should be regarded as disease. For the patient it has been his not knowing why he felt or functioned badly or what to do about it, coupled with the belief or knowledge that the healer or physican did know and could provide relief. For the physician, in turn, it has been his commitment to his professional role as healer. From these have evolved sets of expectations which are reinforced by the culture, though these are not necessarily the same for patient as for physician.

The psychobiological unity of man requires that the physician accept the responsibility to evaluate whatever problems the patient presents and recommend a course of action, including referral to other helping professions. Hence the physician's basic professional knowledge and skills must span the social, psychological and biological, for his decisions and actions on the patient's behalf involve all three. Is the patient suffering normal grief or melancholia? Are the fatigue and weakness of the woman who recently lost her husband conversion symptoms, psychophysiological reactions, manifestations of a somatic disorder, or a combination of these? The patient soliciting the aid of a physician must have confidence that the MD degree has indeed rendered that physician competent to make such differentiations.

A challenge for both medicine and psychiatry

The development of a biopsychosocial medical model is posed as a challenge for both medicine and psychiatry. For despite the enormous gains which have accrued from biomedical research, there is a growing uneasiness among the public as well as among physicians, and especially among the younger generation, that health needs are not being met and that biomedical research is not having a sufficient impact in human terms. This is usually ascribed to the all too obvious inadequacies of existing health care delivery systems. But this certainly is not a complete explanation, for many who do have adequate access to health care also complain that physicians are lacking in interest and understanding, are preoccupied with procedures, and are



Head of a Lost Soul, black chalk drawing by Michelangelo

Like his contemporaries including Leonardo, Michelangelo, too, exulted in the beauty of the human form and painted and sculpted bodies with a profound knowledge of anatomy. The supreme example, perhaps, was the gigantic marble sculpture *David* (adapted as motif in the colour illustrations in the preceding pages). In the *Head of a Lost Soul*, Michelangelo steps into the " Church's domain ".

insensitive to the personal problems of patients and their families. Medical institutions are seen as cold and impersonal; the more prestigious they are as centres for biomedical research, the more common such complaints.

The present upsurge of interest in primary care and family medicine clearly reflects disenchantment among some physicians with an approach to disease that neglects the patient. They are now more ready for a medical model which would take psychosocial issues into account. Even from within academic circles are coming some sharp challenges to biomedical dogmatism. Thus Holman ascribes directly to biomedical reductionism and to the professional dominance of its adherents over the health care system such undesirable practices as unnecessary hospitalisation, overuse of drugs, excessive surgery, and inappropriate utilisation of diagnostic tests. [H. R. Holman, *Hosp. Prac.*, **11,** 11 (1976).] How ironic it would be were psychiatry to insist on subscribing to a medical model which some leaders in medicine already are beginning to question.

Psychiatrists, unconsciously committed to the biomedical model and split into the warring camps of reductionists, are today so preoccupied with their own professional identity and status in relation to medicine that many are failing to appreciate that psychiatry now is the only clinical discipline within medicine concerned primarily with the study of man and the human condition. Indeed, the fact is that the major formulations of more integrated and holistic concepts of health and disease proposed in the past 30 years have come not from within the biomedical establishment but from physicians who have drawn upon concepts and methods which originated within psychiatry, notably the psychodynamic approach of Sigmund Freud and psychoanalysis and the reaction-to-life-stress approach of Adolf Meyer and psychobiology. Actually, one of the more lasting contributions of both Freud and Meyer has been to provide frames of reference whereby psychological processes could be included in a concept of disease.

Psychosomatic medicine — the term itself a vestige of dualism — became the medium whereby the gap between the two parallel but independent ideologies of medicine, the biological and the psychosocial, was to be bridged. Its progress has been slow and halting, not only because of the extreme complexities intrinsic to the field itself, but also because of unremitting pressures, from within as well as from without, to conform to scientific methodologies basically mechanistic and reductionistic in conception and inappropriate for many of the problems under study. Nonetheless, by now a sizable body of knowledge, based on clinical and experimental studies of man and animals has accumulated. Most, however, remains unknown to the general medical public and to the biomedical community and is largely ignored in the education of physicians.

The fact is that medical schools have constituted unreceptive if not hostile environments for those interested in psychosomatic research and teaching, and medical journals have all too often followed a double standard in accepting papers dealing with psychosomatic relationships. Further, much of the work documenting experimentally in animals the significance of life circumstances or change in altering susceptibility to disease has been done by experimental psychologists and appears in psychology journals rarely read by physicians or basic biomedical scientists.

Biomedicine as science and as dogma

What is being and can be done to neutralise the dogmatism of biomedicine and all the undesirable social and scientific consequences that flow therefrom? How can the clinician be helped to understand the extent to which his scientific approach to patients represents a distinctly " human science ", one in which " reliance is on the integrative powers of the observer of a complex nonreplicable event and on the

experiments that are provided by history and by animals living in particular ecological settings", as Margaret Mead puts it?

The history of the rise and fall of scientific dogmas throughout history may give some clues. Certainly, mere emergence of new findings and theories rarely suffices to overthrow well-entrenched dogmas. The power of vested interests — social, political and economic — are formidable deterrents to any effective assault on biomedical dogmatism. The delivery of health care is a major industry, considering that more than 8 per cent of our [US] national economic product is devoted to health. The enormous existing and planned investment in diagnostic and therapeutic technology alone strongly favours approaches to clinical study and care of patients that emphasise the impersonal and the mechanical. For example, from 1967 to 1972, there was an increase of 33 per cent in the number of laboratory tests conducted per hospital admission. Planning for systems of medical care and their financing are excessively influenced by the availability and promise of technology, the application and effectiveness of which are often used as the criteria by which decisions are made as to what constitutes illness and who qualifies for medical care.

The professionalisation of biomedicine constitutes still another formidable barrier. Professionalisation has engendered a caste system among health care personnel and a peck order concerning what constitute appropriate areas for medical concern and care, with the most esoteric disorders at the top of the list. Professional dominance "has perpetuated prevailing practices, deflected criticisms, and insulated the profession from alternate views and social relations that would illuminate and improve health care" [Holman].

Under such conditions it is difficult to see how reforms can be brought about. Certainly, contributing another critical essay is hardly likely to bring about any major changes in attitude. The problem is hardly new, for the first efforts to introduce a more holistic approach into the undergraduate medical curriculum actually date back to Adolph Meyer's programme at Johns Hopkins, which was initiated before 1920. At Rochester, a programme directed to medical students and to physicians during and after their residency training, and designed to inculcate psychosocial knowledge and skills appropriate for their future work as clinicians or teachers, has been in existence for 30 years. While difficult to measure outcome objectively, its impact, as indicated by a questionnaire on how students and graduates view the issues involved in illness and patient care, appears to have been appreciable. In other schools, especially in the immediate post-World War II period, similar efforts were launched, and while some flourished briefly, most soon faded away under the competition of more glamorous and acceptable biomedical careers. Today, within many medical schools there is again a revival of interest among some faculty, but they are few in number and lack the influence, prestige, power, and access to funding from peer review groups that goes with conformity to the prevailing biomedical structure.

Yet today, interest among students and young physicians is high, and where learning opportunities exist they quickly overwhelm the available meagre resources. It would appear that given the opportunity, the younger generation is very ready to accept the importance of learning more about the psychosocial dimensions of illness and health care and the need for such education to be soundly based on scientific principles. Once exposed to such an approach, most recognise how ephemeral and insubstantial are appeals to humanism and compassion when not based on rational principles.

Clearly, the gap to be closed is between teachers ready to teach and students eager to learn. But nothing will change unless or until those who control resources have the wisdom to venture off the beaten path of exclusive reliance on biomedicine as the only approach to health care. The proposed biopsychosocial model provides a blueprint for research, a framework for teaching, and a design for action in the real world of health care. Whether it is useful or not remains to be seen. But the answer will not be forthcoming if conditions are not provided to do so. In a free society, outcome will depend upon those who have the courage to try new paths and the wisdom to provide the necessary support.

Prof. Engel is Professor of Psychiatry and Medicine at the University of Rochester School of Medicine, New York.

[The original expanded version of the article, adapted from material presented as lectures at various US institutions in 1976, appeared in *Science*, **196,** 129–136, 8 April 1977.

IN LIGHTER MOMENTS

The American palaeontologists Othniel Charles Marsh and Edward Drinker Cope were always at loggerheads. Because of their competitive hurry to produce more papers, the feud between the two resulted in many mistakes and often put them into a rather comic plight. Thus, when Cope, mounting the skeleton of a 14 metre swimming lizard, *Elasmosaurus platyurus*, put its head on the wrong end, Marsh immediately pounced on Cope's mistake. Cope retaliated by pointing out that Marsh had mistaken a horned lizard for a bison. Ultimately things came to such a head that they aired their grievances in the local newspapers. A local poetaster writing on behalf of Cope, addressed Marsh thus :

You stole your evoluted horse from
Kovalesky's brain,
And previous people's fossils smashed
from Mexico to Maine.

To which Marsh replied:—

Your reference to a horncone on an
ischium sends a chill.
Professor Huxley is my friend and so is
Buffalo Bill.

(Buffalo Bill Cody had spent a day with Marsh's party in 1870 and later accompanied him on some of his expeditions.)

Major John Powell, of the US Geological Survey, joined the fray by attacking Cope :

Through natural selection's law you are,
as I'm alive,
Of all survivals found, the least fit to
survive.

* * *

Karl Landsteiner, discoverer of the A, B and O blood types in man, was sceptical of the efficacy of electrophoresis for distinguishing and separating closely related chemical substances. However, when Lewis G. Longsworth, of the Rockefeller Institute, demonstrated to him its sensitivity by separating a mixture of guinea hen and duck albumins, Landsteiner became such an ardent proponent that he submitted everything that came his way to electrophoresis, and was always on the lookout for new material to test.

One day he stopped a man leading a donkey along a New York street with a request for some of the donkey's blood for sampling. The donkey-driver, however, refused, saying, "This donkey is going on the stage of the Metropolitan Opera and cannot afford to lose any blood!"

* * *

Particles or waves? The argument on the nature of light has been raging for long. An indication of the complexity of its nature is revealed in the statement by the famous physicist, Sir William Bragg: "Light behaves like waves on Mondays, Wednesdays and Fridays, like particles on Tuesdays, Thursdays and Saturdays, and like nothing at all on Sundays."

B. F. CHHAPGAR

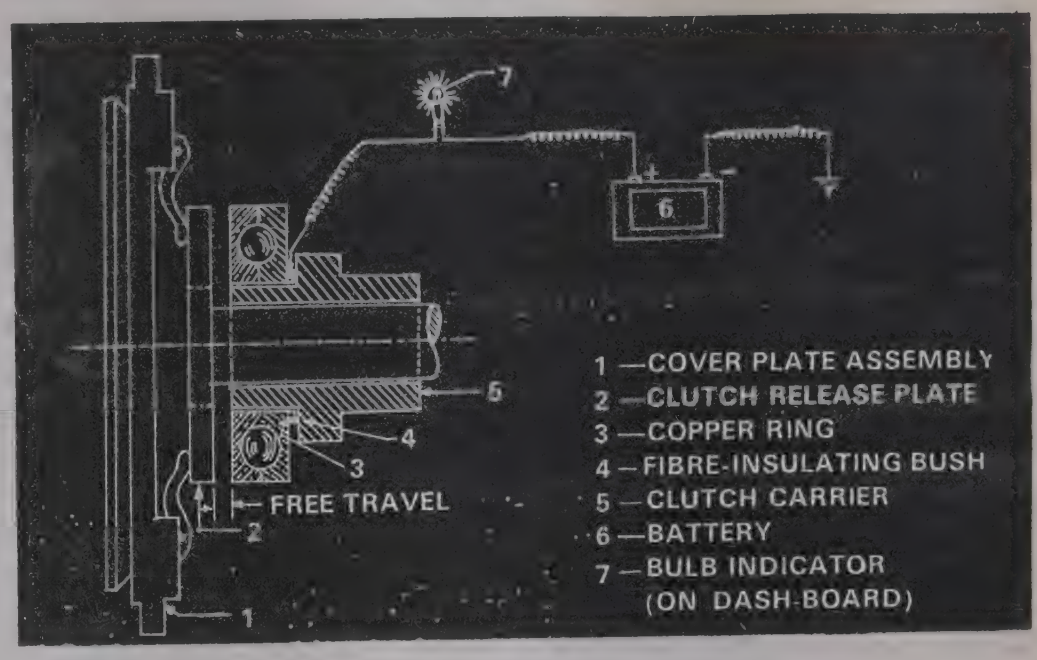
Free-travel indicator for heavy dumpers

Free-travel, the initial free movement of the release bearing until it contacts the release lever plate, is essential for effective operation of the driven disc clutch system used in vehicles. However, as a result of the wearing out of the clutch discs, the free-travel continuously decreases and the release lever plate keeps on moving closer to the release bearing, until the two jam against each other in a sort of a permanent embrace. Such a situation leads to continuous clutch wearing out, thrust on the crankshaft, and gradual overheating of the clutch and the engine.

This free-travel, also called the 'air gap' that isolates the release bearing from the release lever plate, must, therefore, be checked and adjusted frequently by vehicle operators. However, unlike the drivers of transport vehicles, the operators of heavy vehicle dumpers cannot perceptibly feel the free-travel gap simply by depressing the pedal, because the dumpers are equipped with heavy-duty, air-assisted clutches designed to transmit as much as 300 HP.

Mr. B. R. Chadha, Area Superintendent, Beas-Sutlej Link Project, has now come up with a new device especially designed to warn the operators of heavy vehicle dumpers about the impending trouble in respect of free-travel. It is essentially an electrical circuit — normally open — which closes whenever the air gap becomes zero — that is, when the release lever plate makes a metal-to-metal contact with the release bearing. When the circuit closes, a small indicator bulb automatically lights up for the duration of the contact. If the free-travel is completely absent, the plate-bearing contact will be permanent and there will be a constant glow of the indicator bulb. The device thus keeps the operator posted about the condition of the free-travel gap.

To fit the new device on a heavy vehicle dumper, a small modification of the release bearing carrier is necessary: it has to be electrically insulated from the bearing by inserting a 1·5-mm thick bush of bakelite or ebonite in between the two. An insulated wire from the release bearing is then connected to one of the terminals of a battery, the other being earthed to complete the circuit. A small 12 V bulb is mounted on the dashboard and put in series in the circuit. The new device is foolproof, says Mr. Chadha. Even grease or oil which has leaked over the bush does not affect the insulation or the working of the system. The device costs only Rs 100 per unit.



BADIUDDIN KHAN

High heat flux surfaces

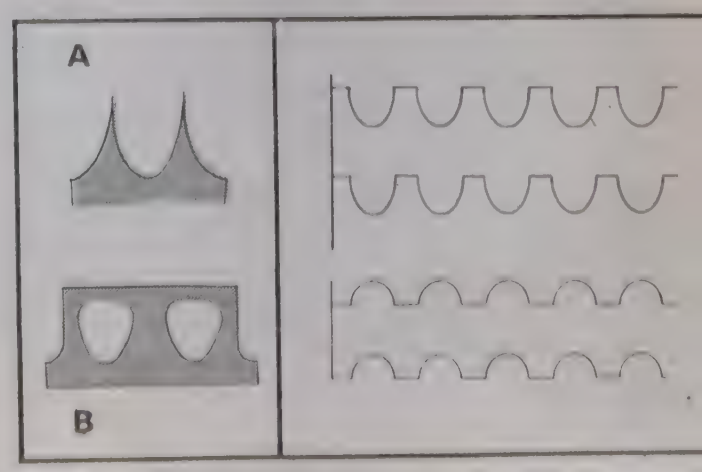
High heat flux surfaces, plane or circular pipes, have been recently developed for obtaining a higher rate of heat transfer for a given wall superheat. Such surfaces have, specifically, been found to be useful for boiling and condensation. In boiling, it has been observed that for polished surfaces and pure liquids (not containing any dissolved gases), the wall superheat (difference between wall temperature and saturation temperature of the liquid, see box) required to start boiling is quite appreciable. The boiling sites also, when boiling gets initiated, are not uniformly distributed over the whole boiling surface. Besides, the wall temperature needs to be fairly high before any of the microcavities get activated for boiling. On a smooth surface, for example, stainless steel or glass, there are hardly any surface defects or cavities; as a result, one requires to heat the surface to a fairly high temperature before boiling starts. Artificially roughened surfaces or surfaces having defects during their preparation contain cavities of varied sizes below them which can get activated.

There are applications, especially in refrigeration and air or gas fractionation, where the wall superheat available, or which can be made available, is quite small. That boiling can be initiated and the rate of heat transfer can be fairly high even with low wall superheats is a great advantage for many of these applications. If high flux surfaces, where this can be achieved, are available cheaply (which is not the case), even day-to-day boiling applications can be considered.

In principle, high flux surfaces are obtained by shaping out saw-toothed or similarly shaped protrusions in rows (with pitch of a millimetre or less) very close to one another, but in a definite orientation, depending on the application, a metal plate or tube, by means of a specially designed tool. The protrusions, when they cover the entire surface, act as fins with pointed edges and help in obtaining dropwise condensation; this, in turn, increases the heat flux. (There are two types of condensation on a metal surface — film condensation and dropwise condensation. In film condensation, the liquid condenses in the form of a film, which reduces further heat transfer. In dropwise condensation, the vapour condenses in the form of drops; heat flux for dropwise condensation is appreciably more than it is for film condensation.) The grooves between different rows serve to store the condensate temporarily which trickles in the form of drops leading to dropwise condensation. The sketch below shows the protrusions with the length and pitch.

These saw-toothed sharp edges are folded in a transverse direction to give a structure similar to the one given in Fig. B. This folded structure below

Fig. A (top row) Two views of the saw-toothed protrusions on metal surfaces used for condensation applications
Fig. B (bottom row) Two views of the folded structure of the surfaces



the surface helps in trapping the vapour below the surface, and a continuous stream of bubbles is ensured from the artificial cavities. Moreover, relatively large cavities produced in this manner get activated even with a small wall superheat.

Such surfaces can be made out of copper, aluminium and steel. Basically, for condensation, the increase in heat flux is due to the increased surface area and dropwise condensation; for boiling, it is due to a sudden activation of artificially created cavities even with a small wall superheat. As there is a limit to the number of artificial boiling sites that can be provided due to the finite size of cavities, high wall superheats may not give much advantage. This is because there are no microcavities, which could be activated at high wall superheats, as is the case for boiling with commercial surfaces. It is expected, therefore, that the use of the so-called high flux surfaces will be limited to applications where low wall superheats are available, for instance, refrigeration and air fractionation, especially where an evaporator-condenser combination can be used. In such cases, the size of the unit would become substantially small with resultant economy in operating costs over a period of time.

S. P. MAHAJAN

THE BOILING PROCESS

It is known that heat travels from a higher temperature to a lower temperature. The higher this temperature difference, the higher would be the rate of transfer of heat. The rate of transfer of heat per unit area per unit time is called the heat flux. When a liquid is boiled, the temperature difference available (also called the wall superheat) for heat transfer is that between the hot surface and the saturation temperature of the liquid under prevailing conditions of pressure. All commercial surfaces used for boiling contain very small cavities which are micronic in dimensions, but not necessarily of the same dimension. All these cavities, big and small, are potential boiling sites, provided sufficient amount of wall superheat is made available.

The only way to increase the wall superheat, other conditions remaining the same, is to increase the temperature of the hot surface. It has been observed that less wall superheat is required to initiate boiling at bigger cavities compared to small ones. The bigger cavities are activated first, if the wall temperature of the heating surface is increased. If the temperature of the wall is further increased, more and more of the smaller cavities become active for boiling (an active boiling site is where vapour bubbles form, detach and move away such that a chain of vapour bubbles, rapidly following one another, is formed with a high frequency and the whole thing looks like a string). If the wall superheat is further increased, a stage is reached when practically all the sites, small or big, become active and the rate of transfer of heat, or the heat flux, increases very substantially even with a minute increase in the temperature of the surface. This is called fully developed boiling. With further increases in the temperature of the metal surface, there is hardly any increase in the heat flux, as the vapour covers and binds the hot surface and the insulating gas cover so obtained even reduces the heat flux.

On a smooth and polished surface, the size of the microcavities is very small. The wall temperature or the superheat of the metal surface required for starting boiling will be comparatively large. If, however, a scratch is made on this surface or the surface is artificially roughened, boiling begins even with small wall superheat. It has been further observed that if some vapour space is provided below these cavities, boiling begins even at lower wall superheats. To get an idea of wall superheats required for full boiling of water with different surfaces, the hot metal surface and the boiling temperature of water (that is, 100°C at atmospheric pressure) required for full boiling with a smooth surface may be of the order of 10°C or more. If the metal surface is filed artificially, it may be around 5°C and with a surface with artificial cavities, it may be 1°C or less.

S.P.M.

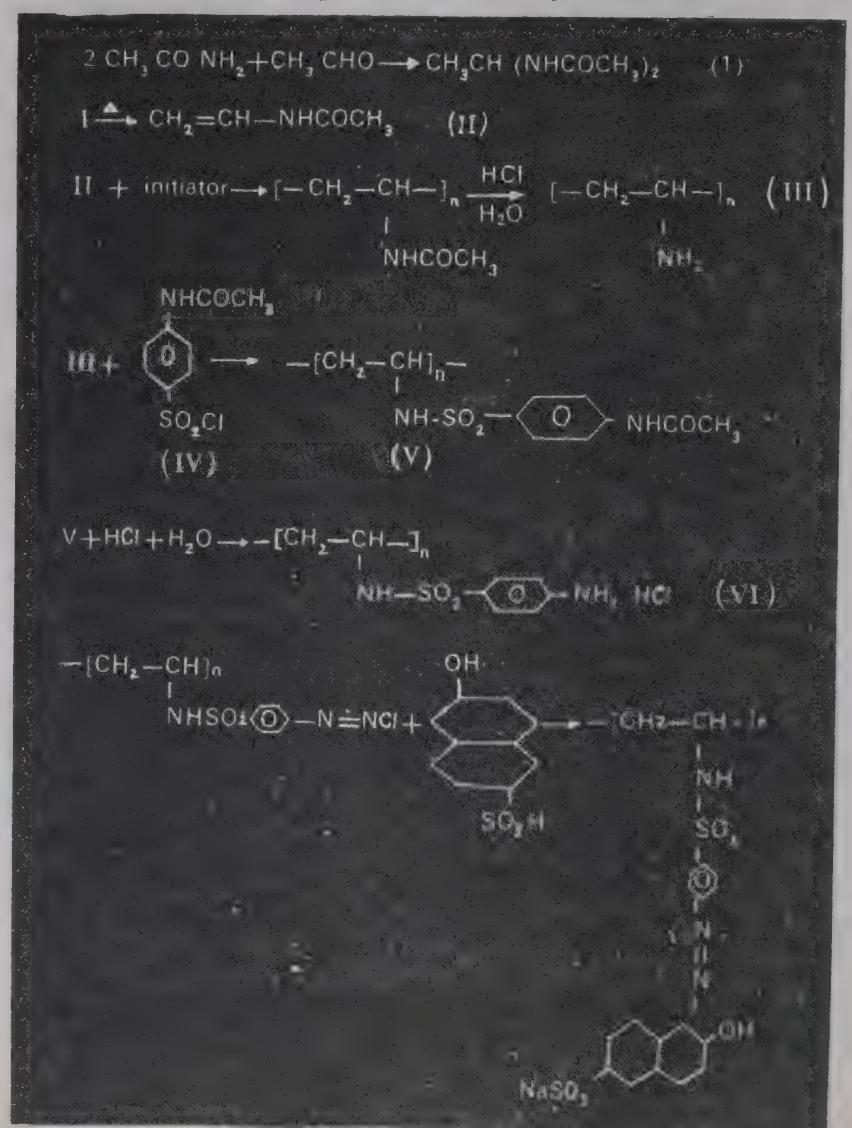
Safer food colours

One of the food additives under constant watch and attack is food colour. Though a variety of colours are claimed to be harmless, there are only a few which have proved so. And some products, which were found to be safe initially, were discovered to be harmful on longer use and, hence, discarded. Chemists use various techniques to make the colours unabsorbable in the body. One of the recent methods is to chemically attach the dye molecule to a polymer backbone. The large size of the polymer molecule inhibits the diffusion of the colour-polymer molecule through the intestine.

But the polymeric dye should have a high colour strength, solubility in the pH range 2 to 8, and still be inexpensive. The synthesis of such a polymeric dye, which can be safely used as a food colour, has been reported recently.

The synthesis can be divided into three parts: (*i*) formation of a polymer which has a pendent functional group, (*ii*) reacting a diazo component with the pendent group of the polymer, and (*iii*) diazotisation of the polyamine and coupling with the coupling component.

Polyvinyl amine has been used for the first part. Though various routes to make polyvinyl amine have been suggested in the literature, invariably the product is not pure and the yields are low. To overcome this, a new route to polyvinyl amine has been investigated. Vinyl acetamide is first prepared by reacting acetamide with acetaldehyde in acidic conditions to give ethylidene *bis* acetamide (I). By heating the product, vinyl acetamide (II) is obtained (90 per cent yield).



Vinyl acetamide so obtained is polymerised using a standard polymerisation initiator to give a polymer of 30,000 to 200,000 molecular weight. The polymer is boiled with hydrochloric acid to give polyvinyl amine (III). The amino group so liberated is reacted with a diazo component (N-acetylsulfanilyl chloride, IV). The polymer (V) is again hydrolysed with water and HCl to give a polyamine. Polymer (VI) is rapidly diazotised with sodium nitrite solution. The diazonium salt is coupled with alkaline sodium-2 naphthol 6-sulfonate.

V. C. MALSHE

the science behind throwing the javelin

JAL D. PARDIVALA

At one time, throwing the javelin was the monopoly of the Scandinavian countries, especially Finland, which still has 100 throwers with figures of over 70 metres (229 ft) and 150 throwers over 67 metres (220 ft). In the *Progressive World Record List Book* (prepared by the International Amateur Athletic Federation), from 1912 to date, six names of the "sons of Suomi" (Finland in its native tongue is called "Suomi") appear. And one name, that of Matti Jarvinen, repeats itself 10 times. He came to be called "Mr. Javelin"; from August 1930 till June 1936 he kept on improving the world record — from 71·57 metres (234 ft 9 in) in 1930 to 77·23 metres (253 ft 4 in) in 1936, and collected on the way the 1932 Los Angeles Olympic Games gold medal.

Two years later, Jarvinen's protege and compatriot Yrjo Nikkanen carried the mark on to 78·70 metres (258 ft 2 in) — a record that stood unbeaten for almost 15 years until an American Franklin "Bud" Held took over the leadership. Held was chiefly responsible for the spectacular advance in javelin distances during the 1950s. He made researches into the characteristics of flight and landing attitudes of javelins and designed the first aerodynamic model.

The javelin was first introduced in the 1908 Olympic Games at London and from that year till Montreal 1976, Finland secured the gold medal five times, the silver six times, the bronze four times; 4th place eight times; 5th place thrice; and the 6th place four times. A very worthy achievement for a country the size of Rajasthan in India.

However, the greatest javelin thrower has been the Russian Janis Lusis. Melvyn Watman in his *Encyclopedia of Athletics* writes: "In an event — the javelin — in which an athlete's performance often fluctuates widely, Janis Lusis has been the personification of consistency. A combination of outstanding competitive ability over a period of many years, plus a smattering of world record throws, makes him the greatest javelin *artiste* of all time — surpassing even the achievements of Finland's Matti Jarvinen."

The most important factor in any throwing event is the *velocity of the implement as it leaves the hand.* The following figures arrived at by some mechanical engineering students are worth noting. If the weight man (shot putter) wishes to throw 15 metres (about 49 ft), the implement should leave the hand at 9·29 metres (30 ft 6 in) per second. To achieve 46 metres (about 150 ft) in discus throw, the discus should travel at 19·20 metres (63 ft.) per second; and for a 61 metre (about 200 ft) javelin throw, the speed should be 23·50 metres (about 77 ft) per second. (These figures have been worked out ignoring wind resistance and assuming that the flight is correct.)

The javelin event can best be described as a modification of the overhand throw. The main difference is that the javelin is *pulled through* a greater range of movement, making it both a pull and a throw following a run. The highly skilled javelin thrower is frequently an all-rounder athlete, because he must have good running speed, a high degree of motor co-ordination, good timing and, last but not the least, strength. While persons of various types of physical build have succeeded in this event, the strong and tall athlete has a decided advantage.

Let us now discuss the technique at various stages of the throw. (It is assumed that the thrower is a right-handed person.)

THE GRIP: The "Finnish grip" is the most commonly employed method. In this, the shaft is grasped at the rear end of the cord binding with the *thumb* and *second* finger. The first finger extends along and is somewhat around the shaft, while the second, third and small fingers grip the javelin around the binding. This method permits the javelin to rest in the groove of the palm (Fig. 1). In the "American method", the index finger and the thumb hold the rear end of the binding, the javelin lying in the hollow formed by the thumb and index finger (Fig. 2).

Whatever method the thrower uses, the javelin should rest in the hollow of the hand, with the wrist straight.

THE CARRY: The principle to be established is that the throwing arm must be kept *relaxed* until it starts its action of throw. If the arm is kept

Fig. 1

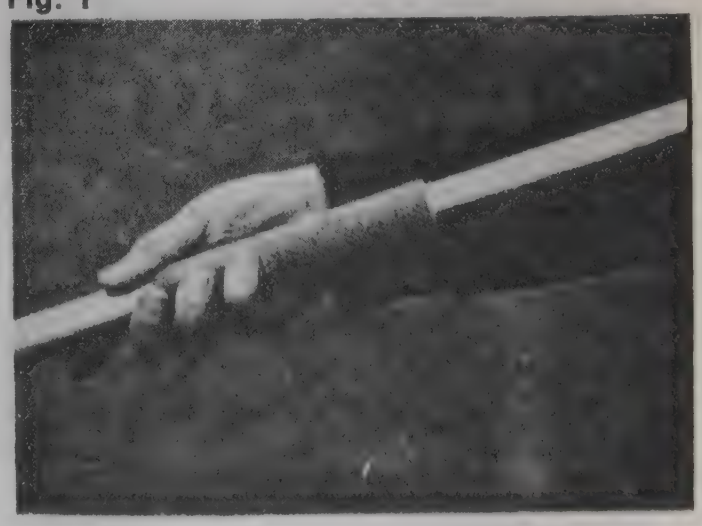


Fig. 2

Fig. 3 The " cross-step "

motionless or rigid, it will tend to tense up. Therefore, throughout the run-up and " cross-step " (Fig. 3), see that the arm is constantly in motion. The free arm with elbow bent at right angles acts as a balance in consonance with the opposite leg. (Right leg-left arm and vice versa.)

THE APPROACH: Because speed is essential to a successful performance, the javelin thrower approaches the second check mark from a distance which permits him to attain as much speed as he can *adequately control*. This mark (first) will be his starting point. The distance between these two check marks (first and second) is covered in four strides. The third check mark is at the end of the eighth stride from the second (Fig. 4). The total distance from the first check mark to the second and from the second to the third will depend on the length of the stride of each individual. The approach is relaxed and the rate of acceleration is constant. It is desirable that check marks are adjusted and standardising of strides done properly during the learning and training process. (See " The Science of The Long Jump " — ' The Approach ', SCIENCE TODAY, March 1977, pp. 46-47.)

It is further suggested that during training and practice, and especially while learning, a straight line is drawn in the middle and perpendicular to the side lines of the javelin throw area (Fig. 5).

THE THROWING PROCESS: The thrower stands near the first check mark with heels and toes parallel and slightly apart. The javelin is carried comfortably over the right shoulder, say, just about ear-height. The extended arm is flexed at the elbow and the tip of the javelin is *tilted towards the ground* and slightly inwards. Several coaches suggest that between check marks 1 and 2, which is the first section of the run, the thrower should put in only one-half speed. Between check marks 2 and 3, the thrower gradually accelerates, so that by the time he reaches check

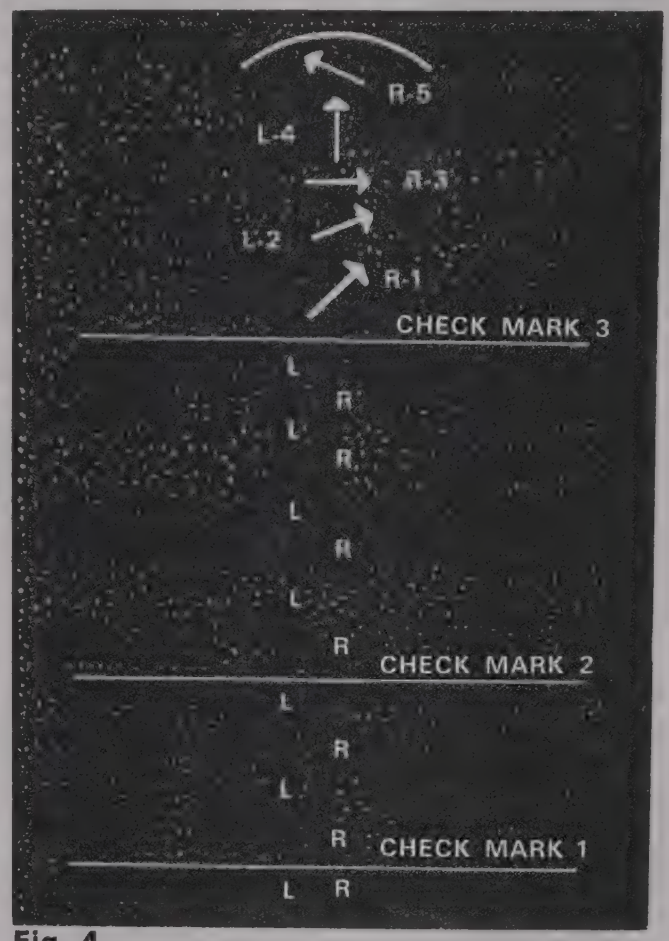


Fig. 4

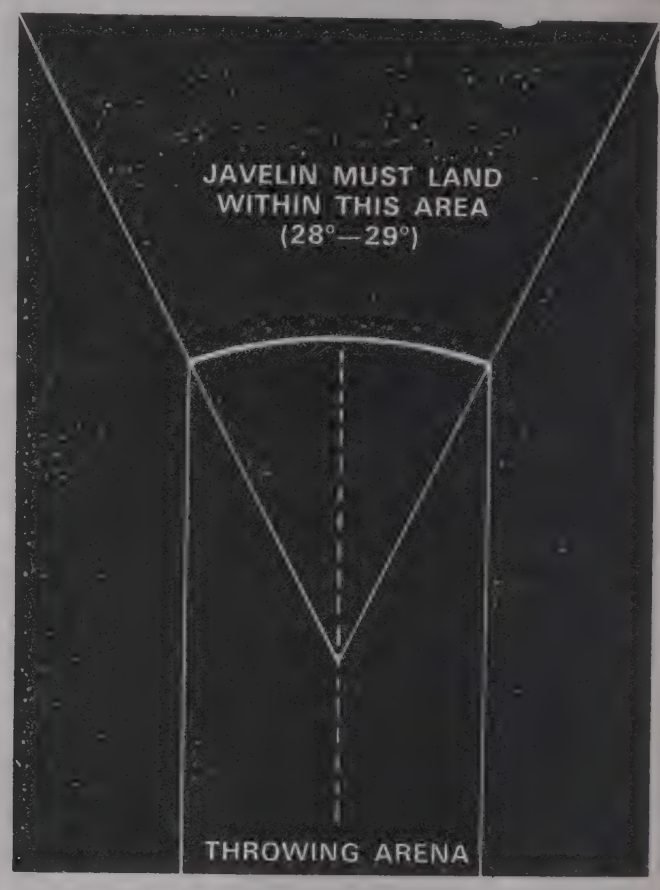


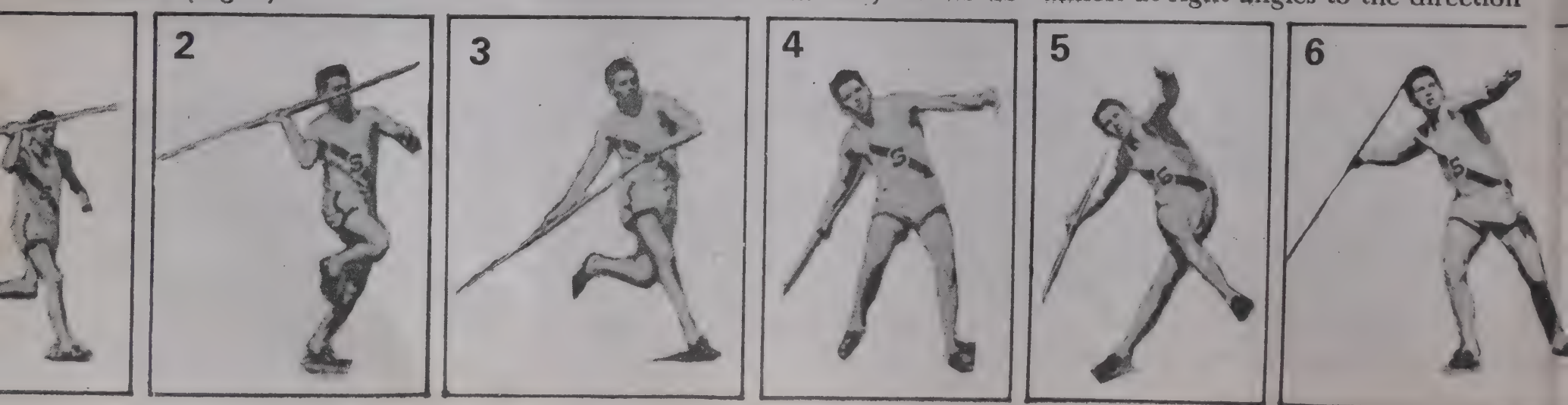
Fig. 5

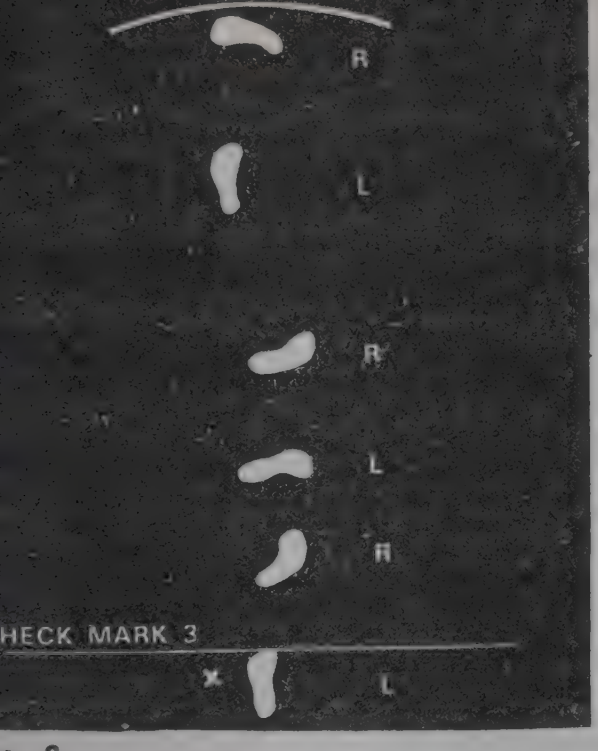
mark 3, the thrower is running at almost 80 to 90 per cent of his full speed. It must be pointed out here that some throwers take two extra steps for jog before they approach the first check mark (to gather speed).

THE CROSS STEP: The heart of the javelin throw technique is the "cross step". It is important and essential for two reasons. First, it initiates more drive from the throwing leg; second, it allows quicker body rotation which provides additional power for the upper body and the throwing arm. In using the "cross step", the thrower should know exactly where to begin his manoeuvre in relation to the foul line, lest he be over the line before the completion of the whole "cross-over" process. At least two metres of space from the foul line (that is, the javelin arc) should be left for the successful management of the whole movement which has to be performed with a certain momentum. Besides avoiding going over the foul line, this much space is also needed for a good and free 'reverse'. The whole process including the 'reverse' covers the last five steps.

Most coaches recommend that it is good practice to count 1, 2, 3, 4 and 5 in rhythm for the last five steps which are involved in the 'delivery' and 'reverse'.

After the left foot strikes check mark 3, on count 1, the right foot strikes the ground with the toes turned slightly outward. On count 2, the left foot strikes the ground, *toes pointing inwards to the right* (Figs. 4 & 6); left hip and side almost face the direction of the throw. (By this time the javelin is drifted back and down so that it is being pulled along behind the throw.) (See sequence 4 of the series in Fig. 7.) On count 3, the right leg executes a front " cross-over " step, the foot landing with the right toe pointing to the right, almost at right angles to the direction





g. 6

f the throw (Figs. 4 & 6). At this ıncture, the upper body from hips ɔove is tilted back to enable the ght leg to make a free sweep forward ɛequence 5 in Fig. 7). This step is ery symbolic, but also difficult to xecute. By this time the javelin ɔes back completely.

On count 4, a good long step is ıken with the left leg; it lands raight in the direction of the throw nd slightly to the left, the weight f the body remaining on the right ip. According to Doherty (Track oach, University of Pennsylvania, nd author of *Modern Track and Field*), ıe placement of the left foot about 0 centimetres (1 ft) to the left of ıe line of the run necessarily means quick forward rotation of the hips so ıat they are at right angles to the ırow very early in the throwing ction. (It is tantamount to saying ıat this sort of placement of the left ɔot brings less tension and strain on ıe right hip when it rotates towards ıe left and into the trunk at the ıstance of throwing.)

It is to be remembered that on no ccount the left leg is to be placed in the bucket, that is, further to the left.

THE THROW: We have seen how the throwing action begins — with the left foot going forward to gain the throwing stance, the javelin in the right arm–back but not fully stretched. If properly co-ordinated and executed, " the cross-over " step with the right and a long stride with the left leg puts the body in a position with the arm and shoulders tilted back. This position subsequently permits a "blast" action.

Just at the instant when the left foot is firmly planted on count 4, the right hip drives forward, rotating towards the left and into the trunk. At this point, the right shoulder is brought forward, with the left arm thrust out towards the left. By now, all the forces from the right toe tip are transferred to the right arm which starts its action of throwing, which is a *pull-through* with the right elbow leading. The angle at the elbow is first shortened and then lengthened as the javelin is released high above the right shoulder (Fig. 8). By this time, the hand lifts the javelin and the body weight is in the process of going over the left foot.

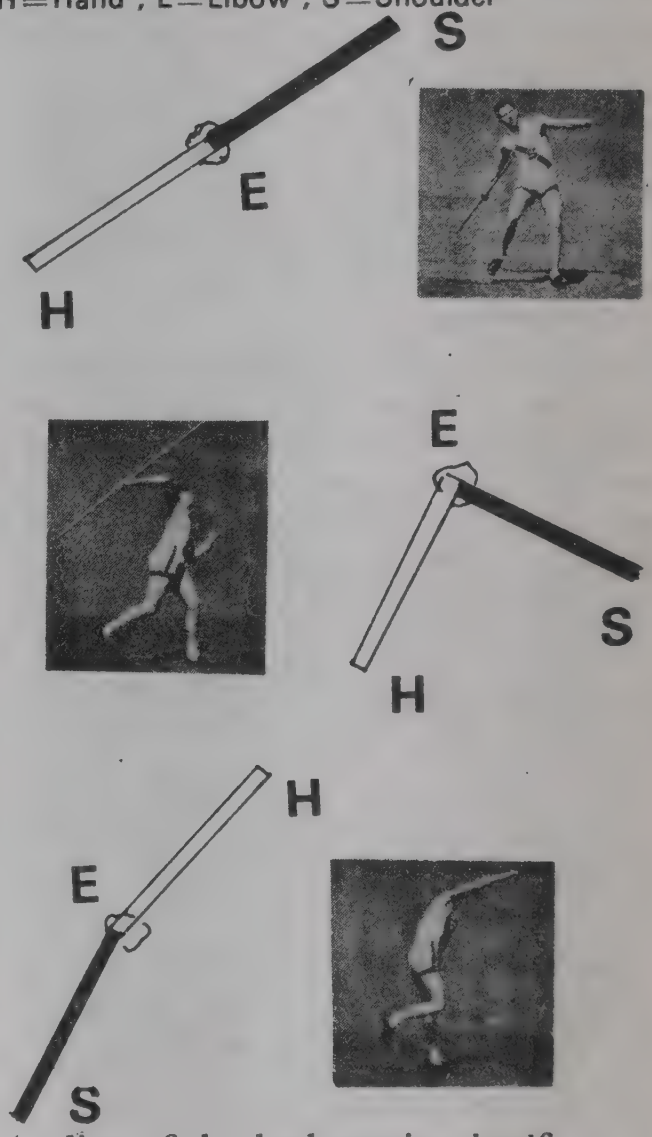
As in putting the shot and discus throw, the left leg which has been thrown well forward will now act as a " brace ". This action will check the forward momentum of the body, and all the forces will transfer upwards to the upper body and the javelin itself. With the body weight now up on the left leg, the javelin leaves the hand at probably between 35 to 40 degrees angle to the ground; the final impetus is provided by a wrist snap as the javelin is released.

THE FOLLOW THROUGH: The last forward step with the right leg is the " follow through " (count 5). If the thrower comes into the proper throwing position and has been able to impart his force to the javelin in a 'ballistic' effort, this force will carry his body forward towards the javelin arc. This " follow through " action is a natural part of the whole event.

A point to remember: at all times check that the flight path of the javelin throughout the approach run, throw and flight is exactly along the line of the body action itself.

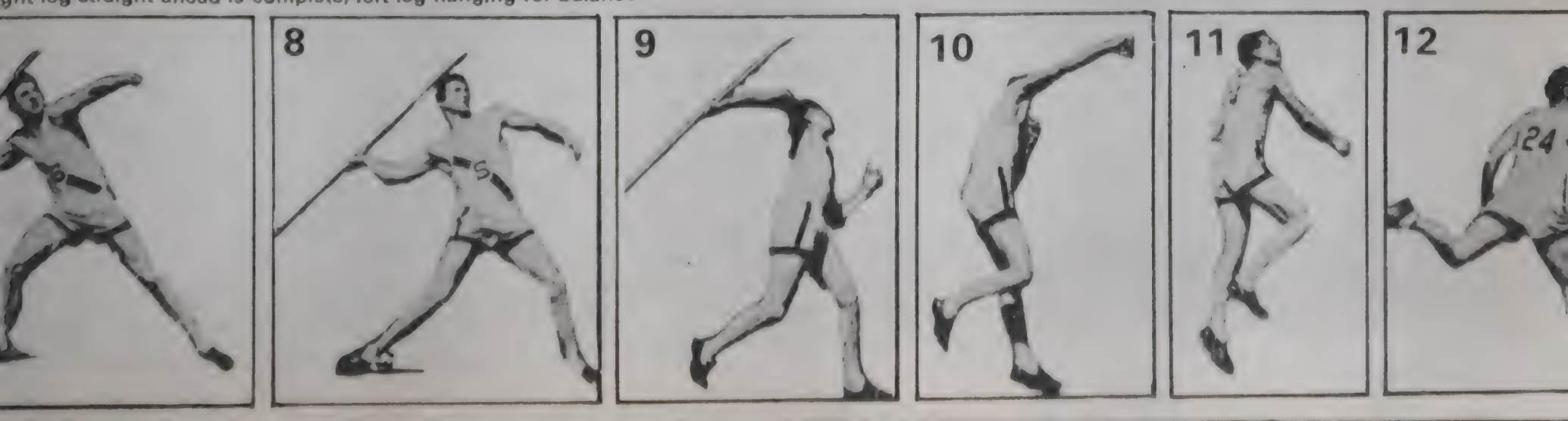
Fig. 8

H = Hand ; E = Elbow ; S = Shoulder



Irrespective of what has been written above, the most satisfactory way of learning correct javelin delivery is from a *standing position* (Fig. 11). After this phase has been mastered, the

ig. 7 A JAVELIN SEQUENCE: (1) After running the desired distance, the thrower approaches mark. (2) As the left foot is near-about check mark 3, ıe spear is taken back, left arm relaxed and synchronised forward with right leg. (3) As the thrower moves forward with easy strides, the javelin goes ack completely ; right foot completes the step on count 1 toes pointing inwards to the right. (4) With a relaxed position, weight shifted back, the left g lands, the foot pointing inwards to the right (count 2) ; the thrower prepares himself for the " cross-over " step with the right leg. (5) The " heart " f the javelin throw, the " cross-over " step. It is executed with left hip facing forward and right shoulder back and down. (The ight leg after execu- on of the " cross-over " step is in the process of landing.) (6) On count 3, the right leg completes the " cross-over " step, foot landing almost at ght angles to the direction of the throw. Throwing arm is not fully extended. The left arm is held forward for balance. (7) In the process of a perfect ınding position after " cross-over " step. Left leg still in the air, right foot flat on the ground. (8) As soon as the left leg lands on count 4, the throw egins. Both feet are on the ground but completely apart. (9) Right hip comes into the throw, pulling right shoulder forward with elbow lead. (10) fter giving the final wrist snap, the throw is completed at the height of the arm. The body is in the process of going up and over the left foot. 11) The beginning of a perfect " follow through ". Eyes focussed on the flight of the javelin. (12) On count 5, the " follow through " with the ght leg straight ahead is complete, left leg hanging for balance



athlete can begin to use forward momentum to assist him in exerting additional force on the javelin. The throwing position that is being learnt and practised from the standing position should be identical to the throwing position at the end of the approach run.

The question of attitude

The Finns believe that throwers must take chances; consistency of performance does not count for much, since it is the *one big throw* which wins the gold medal. They expect their throwers to be erratic and, more importantly, optimistic. If five of the six throws happen to be missed, the athlete must still go back to his mark and let fly, win or lose.

The epitome of the above attitude, in a way, was Miklos Nemeth of Hungary who won the gold last year at the Montreal Games. Yet, everybody had given up hope for him. Way back in 1967, at the age of 20, he was ranked second in the world. However, he didn't fulfil his promise. He failed to qualify in Mexico (1968); finished a weak seventh at Munich (1972), and in 1974 again came seventh at Rome in the European Championships. He was named " the easy-going Miki ". But at Montreal, in the very first round, " the easy-going Miki " unleashed an incredible " la Beamon " — 94·58 metres (310 ft 4 in) — shattering the Olympic record by over four metres and the world record by 50 centimetres. His second and third attempts were fouls, the remaining three falling almost ten metres short, yet, that one big throw won the Olympic gold.

Miklos Nemeth notwithstanding,

Fig. 9 Miklos Nemeth: from " easy-going Miki " to world champion

TRAINING SCHEDULE

Monday : Jog 400 metres and further warm-up with body bending and stretching exercises followed by lead-up weight training exercises. Two lengths of 50 metres for "cross-over" step exercise (Fig. 10). Throw javelin from a standing position several times. Measure check marks and run through several times without actual javelin delivery. Take 4/5 throws for form, followed by further 5/6 relatively good throws for distance. Work with sprinters for a while and jog down.

Tuesday : Warm up as on Monday. Make several short throws into the ground. Run through the approach several times and work for 20 minutes on form followed by 12 throws with good effort. End up with three lengths of 50 metres training for "cross-over" step followed by 4 dashes of 30-metre sprints. Close down with a jog of 400 metres.

Wednesday : Jog 800 metres and warm-up as on Monday followed by weight training exercises. Work with sprinters for 20 minutes. Run through (fast) all the steps from the starting point and try to get into *position for throwing* (Fig. 11) with greater speed — 10 times. After rest, take 4 lengths of 50 metres or 2 lengths of 100 metres for " cross-over " step exercise. If not very tired, after rest, take up six hard throws for distance.

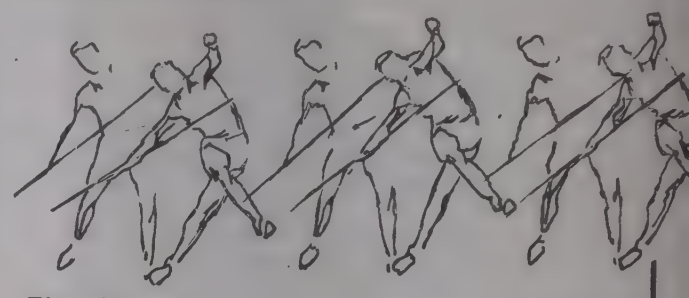


Fig. 10

Thursday : Jog and warm-up as on Monday. Go over 4/5 hurdles (low) half a dozen times for standardising the strides. Throw eight to 10 times with full run but at three-quarter final effort. Rest. Take four lengths of 50 metres for " cross-over " step exercise with weighted belt. End with jog.

Friday : Rest.

Saturday : Competition. If there is no competition, try to throw for distance at least six times.

(Note: Training with heavier implements than the standard ones is a part of the weight training programme.)

most coaches agree that in competition, the first throw should usually not be one for maximum distance. It is felt, a relaxed safe throw often " grooves " the athlete for maximum effort on succeeding throws.

Training

At the outset, it must be made clear that the athlete must never begin his practice sessions unless he is properly warmed-up. The athlete must also remain relaxed and free from tension.

Once the grip has been chosen, the learner should immediately begin to develop control of the javelin itself. This is best done by throwing the javelin initially to a distance of 10 to 15 metres (not on the track or jumping arenas!). These throws should be relaxed and delivered with emphasis on control and accuracy. When the flight pattern has been controlled, the learner should run a short distance and continue to throw. At this stage, there should be no feeling of acting under pressure, as the purpose of the activity is to develop a touch, a feel, a sense which often require several days and hundreds of repetitions.

After a sense of control has been developed, the learner should begin to extend his throws to 20, 25 and 30 metres. These throws are to be made from a standing position (Fig. 11), with the flight (trajectory) of the throws at about 35 to 40 degrees angle. In all these 'standing throw'

Fig 11

European training methods

Jeno Koltai, coach of the Hungarian Olympic team, in his thought-provoking talk " Evolutions of the throwing events at Mexico City " had said, " . . . . European throwers have achieved considerable prog. ss in the field of keeping fit and of technique development.

" I was interested to note the harmonious variation of work with light and heavy implements. The athletes from East Germany in particular excelled in this as they alternately used the lighter and heavier types during each training session. My pleasure in observing this development was greater, because we have ourselves, since the middle of 1950, used this method of alternating light and heavy charges in the training of our athletes. Thus, our shot putt sportsmen train with heavy shots of 8 to 16 kg, and with light shots of 4 to 6 kg; our javelin throwers use 2 to 4 kg heavy shots, iron bars weighing 2 to 3 kg, or 3 to 6 kg heavy balls and lighter javelins weighing 500 to 600 grams used by women. Our discus throwers train using 8 to 10 kg weights and with lighter implements weighing 2·5 to 5 kg.

practices, and even with a run, the energy must be expended into the javelin, making sure that there is minimum of flutter in the javelin in flight.

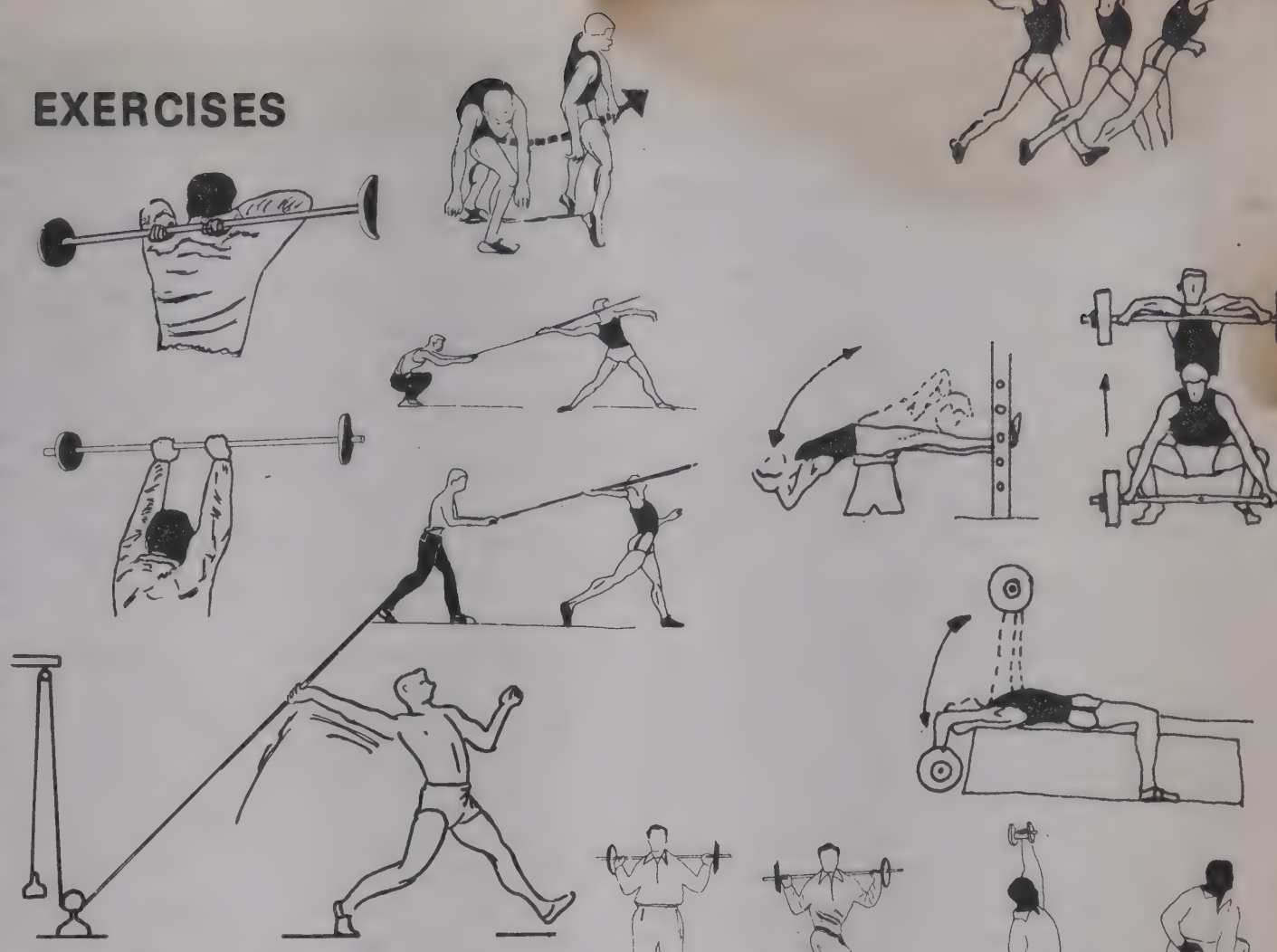
As we had stated in our discussion on the discus (SCIENCE TODAY, May 1977), it is common knowledge that a skill learned at one rate of speed is difficult to maintain at another rate of speed. Thus, javelin throwing from a 'standing' position and from an 'approach run' are two distinct motor skills. This is why the learners should introduce themselves to the 'run and throw' as soon as they are able to control the flight of the javelin.

Once the check marks have been established and the "cross-over" step learnt, the athlete is ready for serious practice.

Success in the javelin depends to a large extent upon speed and strength and their application from a position of balance. To attain these essential factors, hundreds of approach runs with bounding strides, cross steps and turns of the body are to be gone through. Once one has achieved some measure of proportion and power, come the years of perfecting technique.

Good javelin throwing also requires general body development and the training programme must include general conditioning. Pre-season work must include exercises which

EXERCISES



are related to the javelin throw, besides activities that develop leg speed and strength, back and abdominal muscles as well as arm and shoulder girdle strength (see diagrams above).

Usually, to a track enthusiast, swimming is taboo. However, considering the overall body conditioning and arm exercises involved in swimming (over-arm, breast stroke, back stroke, etc), it should actually be excellent for events like the javelin. Kenneth Doherty once remarked that, for many years he had noted with great interest that varsity swimmers who attempted the javelin event after the swimming season was over were able to produce amazingly consistent good performances.

Wood-chopping is also a very good exercise. In fact, the Finns attribute the fact of there being so many first class javelin throwers in Finland to their ancestral heritage of wood-chopping and catching fish with spear. No doubt methodical wood-chopping is a direct adjunct to javelin throwing as the action is very similar to throwing. It further develops those back and abdominal muscles directly involved in javelin throws. But, then, one has to find the opportunity to do so!

"Bud" Held has emphasised that throwing the javelin is the best training exercise there is for javelin throwers. A thrower should never go for much easy throwing for the sake of form. He suggests that it is better to throw for distance twice a week than to throw for form five times a week. He further says, "In throwing for distance in practice, a thrower should learn to get excited, just as he does during competition. If he does not learn to practice with a feeling of excitement he will not be able to use this feeling properly during the competition".

Part of the warm-up should consist of running 100 metres doing nothing but the fast practice of "cross-over" step and that, too, not once but several times (Fig. 10). This mastering of the "cross-over" step is the key to success. It must become second nature to the thrower so that he shall not have to think of it during training or competition.

"Margitta Gummel (at one time world record holder in shot putt and gold and silver medalist 1968 Mexico and 1972 Munich Games), for instance, trained with men's shot until 4 days before the contest in Mexico; and after 18 such throws she still threw twice with a woman's shot attaining a distance of 19 metres (62 ft 4 in). Janis Lusis used a javelin weighing 2·5 kg and in addition he often trained with women's javelins. (The regular weight of the men's javelin is 800 grams, or 1 lb 12·20 oz).

"Before the Olympic Games, I often observed during training that the European throwers strove not only for technical excellence but also for better performance in training. Another change I noted was that in individual training, the number of throwing attempts was larger as compared with past years. All this goes to show that throwers now try to achieve during training the same high standards they hope to attain during the contest; and therefore *subject themselves to as heavy* a strain. This is in keeping with the fundamental principle of capacity development. As everybody knows, *capacity can only be increased if the body is forced to tackle unfamiliar tasks.*

"Training can of course be overdone, and one should always try to avoid extremes."

SHOES

The run-up area for the javelin throw is quite different from the circle for the shot putt and discus throw and the javelin thrower should select shoes which provide not only stability but also add to the efficiency of throwing. Some prefer regular running shoes with two spikes in the heel. Such shoes provide more traction and are useful even on soft or wet runways.

"Bud" Held had once mentioned how little consideration is given to shoes by throwers. "Two things are important concerning a javelin thrower's shoes. The first is that they be very light. Light shoes are every bit as important to a javelin thrower as they are to a sprinter, because the greatest hidden potential a javelin thrower has is the momentum of his run which usually he is unable to transmit to his javelin. Getting into the throwing position and maintaining speed at the same time is one of the most difficult things a javelin thrower has to do, and the heavier the shoes, the more difficult this job becomes. The second thing is that the left shoe (if the thrower is a right-handed person) must have plenty of long spikes — 3 spikes in the heel and at least 5 on the front of not less than 3/4 of an inch in length. On soft grass, even longer spikes are desirable. If the left foot slips, even by so much as two inches, the throw will be considerably impaired."

learn while you play—9

B. D. KELKAR

A. V. DESHINGKAR

How long is a metre? You would think it's a silly question; you would say, "Why, it's marked on any scale or tape measure!" But, did you ever wonder how that particular measure marked on the scale or tape came to be? Well, the story of the metre goes nearly 300 years back in time: in 1670, Gabriel Mouton, who was vicar of St. Paul's Church in Lyons, France, proposed the metre as the basic unit of length — as a fraction of the great circle of the Earth. More than 100 years passed before anybody would consider Mouton's metre. Then, in 1795, France adopted the decimal system of measurement and the *métre* was taken to be *supposedly* one ten-millionth of the distance from the north pole to the equator, along the meridian passing near Dunkirk, Paris and Barcelona.

You noted the word "supposedly"? Scientists today are so particular about accuracy that they have found another definition of the metre: it is 1,650,763·73 wave lengths in vacuum of the orange-red line of the spectrum of Krypton 86 (see Fig. 1, below).

Have you guessed why we have talked about the metre at such length? The reason lies in that term "wave length", because it implies a vibration, a movement up-and-down, or to-and-fro, or in other words, "oscillations". Among all types of motions, the oscillatory motion is perhaps the most important. Every particle (consisting of atoms which comprise protons, neutrons and electrons) vibrates. The light, sound and electro-magnetic waves have vibrations of different types which make them behave differently. The waters in the great seas vibrate with particular amplitude and frequency.

You know what frequency, is, don't you? It's the number of to-and-fro movements every second. And amplitude? It's the extent of displacement from the original position. Fig. 2 gives a clear idea.

Let's now go on to the most common example of oscillatory motion we had studied before (SCIENCE TODAY, January 1977) — the swing of a pendulum. We know now — as Galileo had ascertained with his pulse beat (and we have the stop-watch!) — that it takes about the same time for a narrow swing as for a wide one! This phenomenon — equal times for all amplitudes — has an elaborate name — 'isochronous", a Greek word meaning "equal in time". It is found that all the repeating isochronous vibrations have the same type of motion with the same *shape* of time-graph. This is known as a "sine curve". We call such motion "simple harmonic motion" (SHM).

Let's make a simple device to understand this. The device is shown in Fig. 3. Attach a sketch pen to the pendulum bob and set the pendulum swinging. Now, as you slowly (and with uniform speed) pull the paper from the roll, the swinging sketch pen will draw a graph. This is the sine curve.

We have seen that a pendulum moves with SHM for all amplitudes. Similarly, a load hung from a spring bounces up and down with SHM amplitude over a wide range (Fig. 4). A coiled spring with a load is an elastic system; flexible beams, stretchable wires, twistable rods — all fall within this category. And they all obey Hooke's Law. Let's prepare a simple experimental set-up (Fig. 5). We shall need a coiled spring used inside ball-point pens, a cardboard pan and some weights, say, of 5, 10, 20 and 50 grams. Turn the ends of the spring into hooks with a pair of pliers, hang one end from a nail on a wooden board and from the other end,

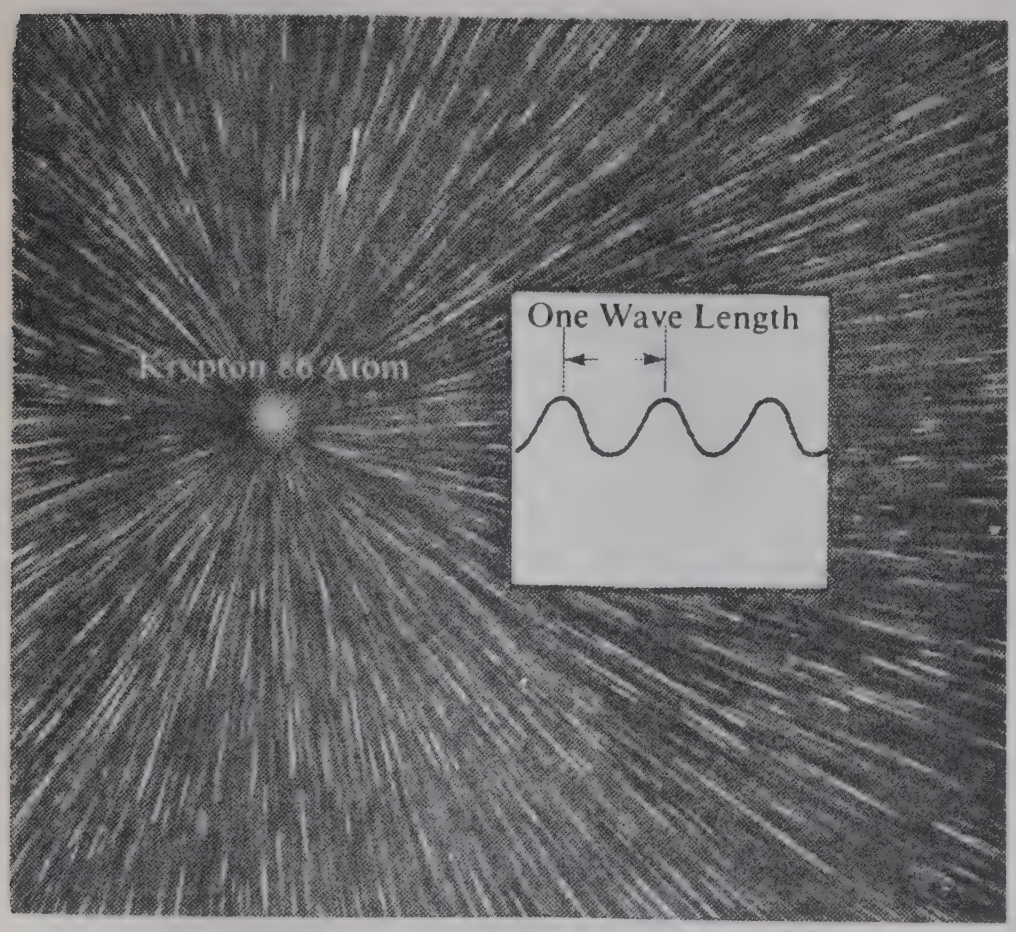


Fig. 1

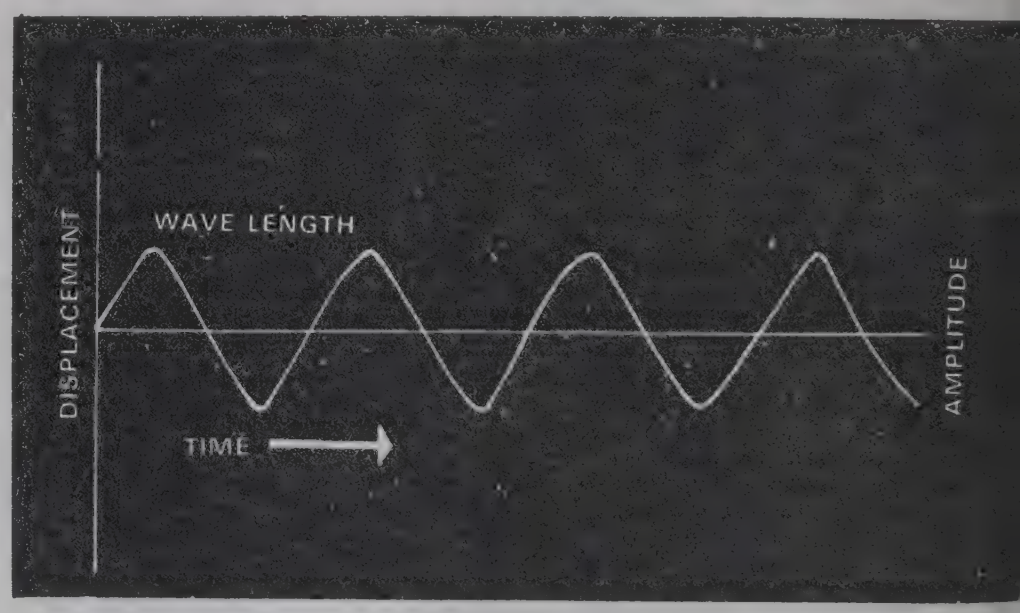
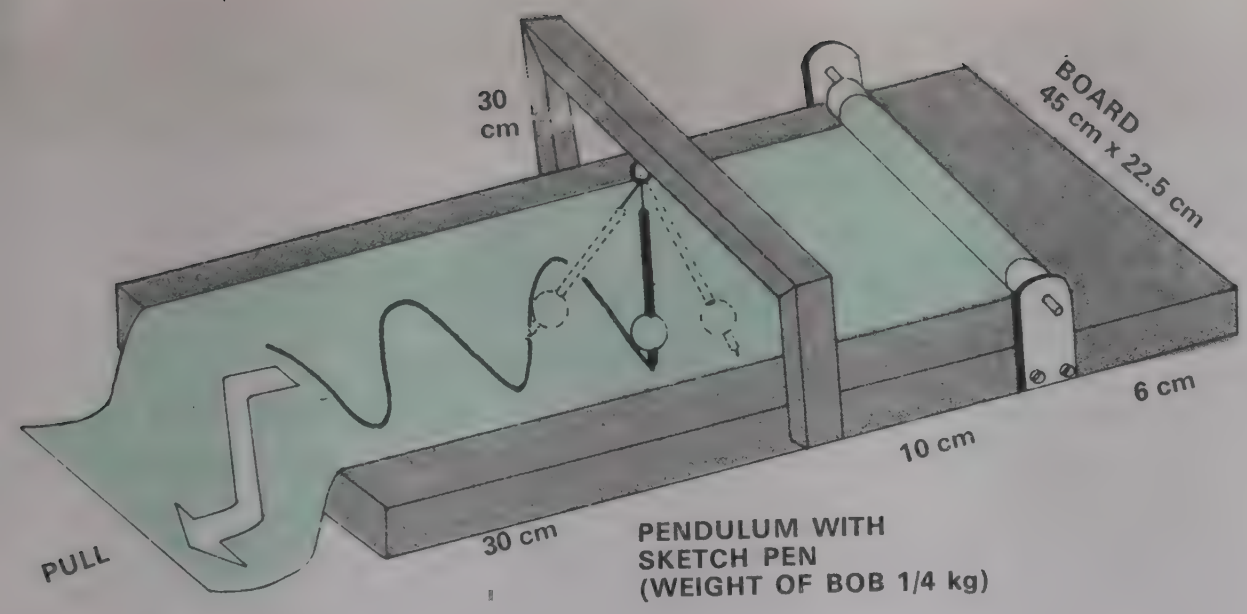
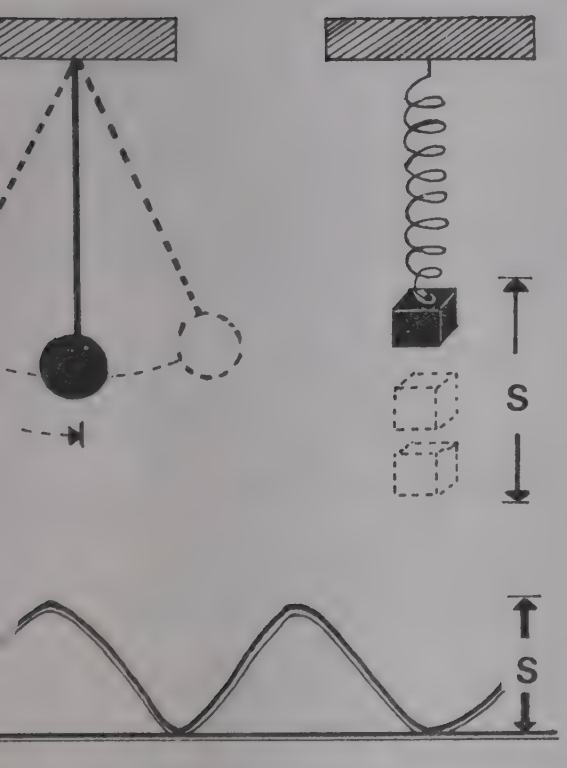


Fig. 2

suspend the cardboard pan. Fix a scale on the board vertically. Place different weights on the pan and mark the spring's extension against the scale. *The increase in the length of the spring will be proportional to the load.* And that is known as Hooke's Law, discovered by Robert Hooke three



g. 3



g. 4

centuries ago. You can easily notice that the load required for each centimetre expansion in the spring will be constant for the elastic range of the spring and is known as " spring constant-K ". It can be written as

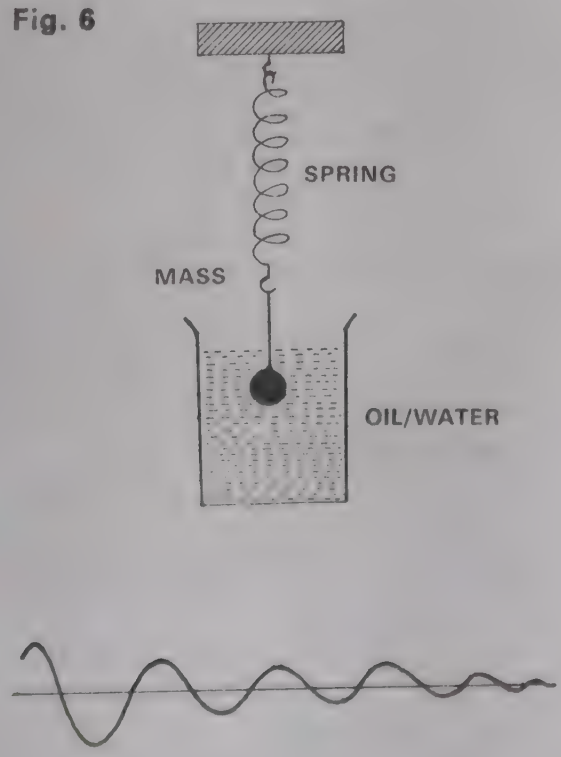
$$\frac{\text{Load (or stress)}}{\text{Elongation (or strain)}} = \text{Constant.}$$

g. 5

Suppose we pull the spring and let it go! The spring will oscillate up and down freely. The vibrations will continue for several cycles. (This is known as free vibrations with spring-mass system.) If we plot the positions of the pan-end of the spring at different points of time, the graph will resemble a sine curve for several cycles. But, then, the resistance of air and the internal resistance of the spring will gradually overcome the oscillations and the graph will show a gradual decrease in amplitude (Fig. 6). This is known as *damping*. Take a tin filled with water and sink the mass into it. You will find the oscillations are slowing down rapidly. If, instead of water, we use some thick oil (say, lubricating oil), the oscillations will die down much more rapidly.

Figures 7 and 8 show two simple toys you can fabricate using the principle of the spring-mass system.

Fig. 6



If you walk about a car repairing workshop (or its backyard), you might come across a piece of thrown-away coiled spring generally used as a shock absorber in cars. Bring it home, place it on a table and place a hardboard on top of it. Now, first bang the table with a hammer and then hit the top of the hardboard on the spring (Fig. 9). Which blow felt harder at the grip of the hammer? The answer is obvious, isn't it? The spring got compressed by the blow and, therefore, offered less resistance. Now you know how springs

Fig. 9

NODDING JOKER

Take a spherical wooden ball and glue facial features cut out from cardboard (or paint them on). Fix a spring to it with a nail. Fix the other end of the spring on a longer cylindrical piece of wood ; you can "dress up" this piece to resemble a human torso. The joker will nod his head with the slightest jerk given to it.

Fig. 7

FLYING BIRD

Prepare the body and head of a bird with clay or plaster of Paris. While you are making the body, insert four springs — one each for the head and the tail and two for the wings ; also insert a hook for tying a string. Let the model dry. Make the wings and tail using feathers and attach these to the respective free ends of the springs. Tie a string to the hook and holding the other end, give it a jerk. The wings, head and tail will start oscillating, simulating the flight of a real bird.

Fig. 8

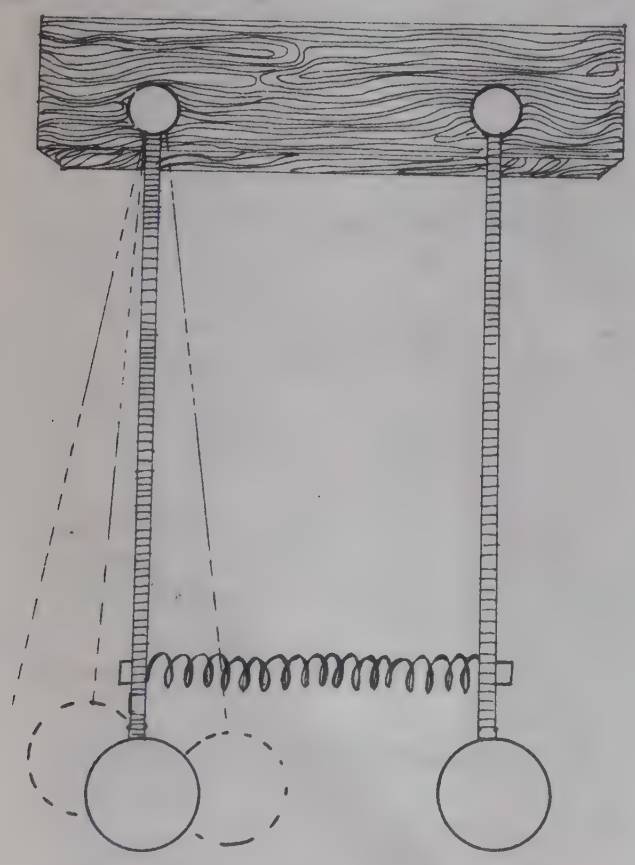
act as shock-absorbers in the wheels and axle-mountings in vehicles. On uneven surfaces, the wheels receive jerks or shocks which get transferred to the flat or coiled springs (Fig. 10). The springs get compressed and, as a result, the chassis or body of the vehicles receive much less jerk.

Fig. 10

Twin-pendulum

We have already seen how the oscillations of a simple pendulum are periodic like a spring-mass system. Let's now prepare an interesting set-up of a "twin-pendulum" (Fig. 11). We need just two metal bobs (or big wooden spheres) of about 100/150 grams each, two pieces of galvanised wire (3 mm size) about 30 cm long and a thin spring about 3 to 4 cm long. Turn one end of the wires into hooks and pass the other end through holes made in each sphere; you get two pendulums; see that the lengths are the same. Now, hang the pendulums from two nails on a wooden board. Bend each end of the spring into a hook and, then, attach it to the two pendulum wires; the spring must be slightly *taut*.

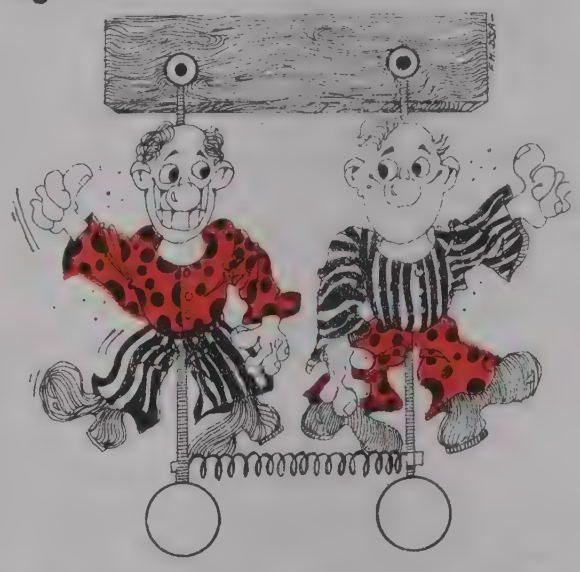
Fig. 11



What happens if you oscillate one of the pendulums? Strangely, the two pendulums will oscillate *alternately*. Can you work out the reason behind this? It's quite simple really: the "interlinking" spring absorbs the energy during every oscillation of a pendulum and feeds part of it to the other one. Thus, the swinging energy of one is passed to the other through the spring. The cycle is repeated until all the energy is dissipated away due to friction at the hinges and, of course, due to air resistance. Just for fun, cut out two figures from cardboard and attach them to the pendulum wires (Fig. 12).

How about some more experiments with vibrations and oscillations? Two such projects are shown in Figs. 14 and 15. If you are electronically-minded, you could work out some toys with small electric motors. Two such models are shown in Figs. 13 and 16.

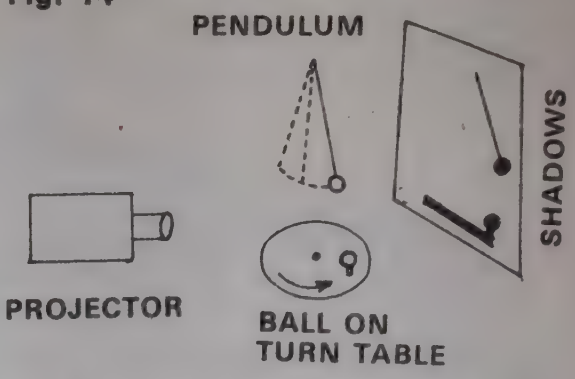
Fig. 12



We have seen how vibrations are a part of our daily life. In many cases, particularly in machinery, vibrations have to be eliminated by proper balancing of the components and by introducing *damping*. But, then, vibrations are *forced* on certain machines like grading sieves or vibrating screens, used in grading sugar, seeds, grains, etc.

We also know, when a body vibrates, it sets the air around it vibrating, too, and produces sound. Next month, we move on to the world of 'sound'. Remember, sound is essentially *vibrations* produced in an elastic medium!

Fig. 14



MATCHING SHADOWS

We shall need a turn-table (of a gramophone or can make one with a suitably mounted toy electric motor). A wooden ball is fixed on the turn-table. Suspend another ball of the same size from a string. We shall need a light source to project shadows on a white screen or wall. Start the turn-table and, also, let the pendulum swing with an amplitude equal to the turn-table's diameter. Will the shadows of the two balls coincide?

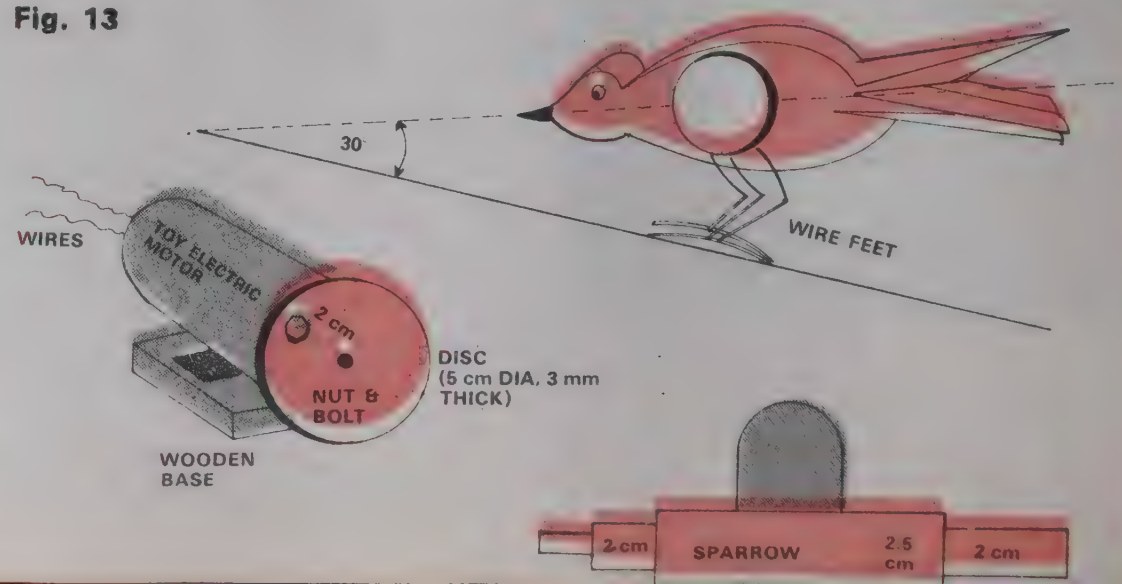
DANCING SPARROW

Take a toy electrical motor and mount it on a wooden base. Fix an aluminium disc (using Araldite) to the motor shaft. Drill a hole 2 cm away from the centre of the disc and fit in a bolt and nut in the hole. Use a dry cell battery and start the motor. You will see that a centrifugal force is produced due to the bolt fixed on the disc and this causes the wooden base to *vibrate*; actually, the base block will move hither and thither due to these vibrations caused by unbalanced force due to the disc's rotation.

Now, cut the outline of a sparrow from a 2·5 cm-thick thermocole sheet. Cut out a hole in the sparrow's body to fit the motor; fix it with Araldite. Now mount a disc with a nut-and-bolt as described earlier and use 3 mm-diameter wire to prepare the sparrow's feet. See that the sparrow balances well on the wire-feet (incline the body of the sparrow through 30° to the ground). Also, remember that the motor has to be placed at the centre-of-gravity of the sparrow (this position can be found by trial and error).

Start the motor by connecting with a dry cell battery. How the sparrow will dance!

Fig. 13



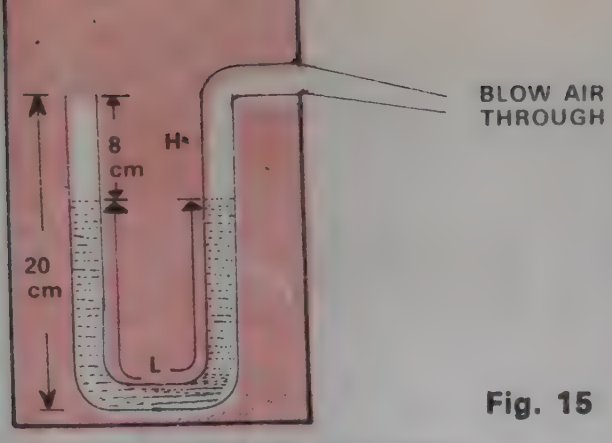


Fig. 15

OSCILLATING WATER COLUMN

Take a U-tube from the chemistry lab and pour some coloured water into it. If you blow in air from one end, the water column will begin to oscillate until the energy of oscillation is dissipated away in friction of water with the glass and also the pressure of air (which is equal at both ends). Vary the free air column (H) in height and measure the number of oscillations in one second. You will find that the number of oscillations per second can be increased by decreasing the length (L) of water column and vice versa.

BIFILAR & TRIFILAR SUSPENSION

This is an experiment with torsional vibrations of a twisted wire. Take two or three 2 mm-diameter long wires (50 cm) and a heavy steel disc, about 1 cm thick and 20 cm in diameter. Attach the lower ends of the wires to the disc by soldering or brazing (in a tinsmith's shop). Attach the upper ends of the wires to the ceiling. Vary the length of the wires and measure the number of oscillations per second (by initially twisting the disc ends of the wires and then releasing). You will find that as the length of the wires decreases, the number of oscillations per second will go on increasing.

In this case, the elastic behaviour of the wires in twisting makes the suspension to vibrate.

PAIN RELIEVER

We use the same principle of a 'vibrator' used in the dancing sparrow. This time, place the motor and disc (with nut and bolt) *inside* a torch body; use proper packing so that the motor fits in properly. Place a single dry cell battery inside, too. On the front side of the torch, fix a wooden peg. As you put " on " the switch, the torch will vibrate. Place the wooden peg against your body and you can feel a soothing " massaging " effect.

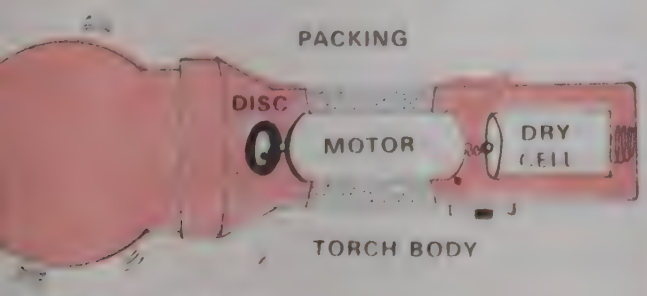


Fig. 16

PUZZLE TIME

• Magic rotor

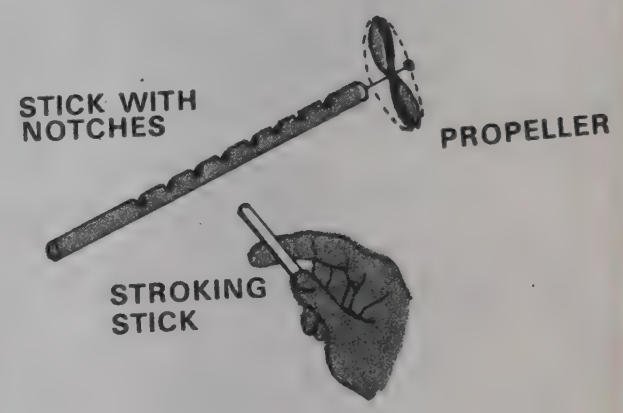
R. W. Leonard, the inventor of this toy, had named it " magic windmill ". And, believe it or not, he wrote about it in one of the most prestigious journals, the *American Journal of Physics*, and that, too, in 1937. Ever since Leonard's paper appeared, scores of physicists and others have taken up the puzzle behind its working, but, it seems, nobody has come out with *the* answer.

The toy is simple. All you need is a small rotor blade and two sticks — one with notches cut into it; the other stick is used for stroking the notches. Pin in the propeller at one end of the notched stick. Hold the notched stick with the forefinger near the far end and the thumb on the near side. Run the other stick back and forth over the notches.

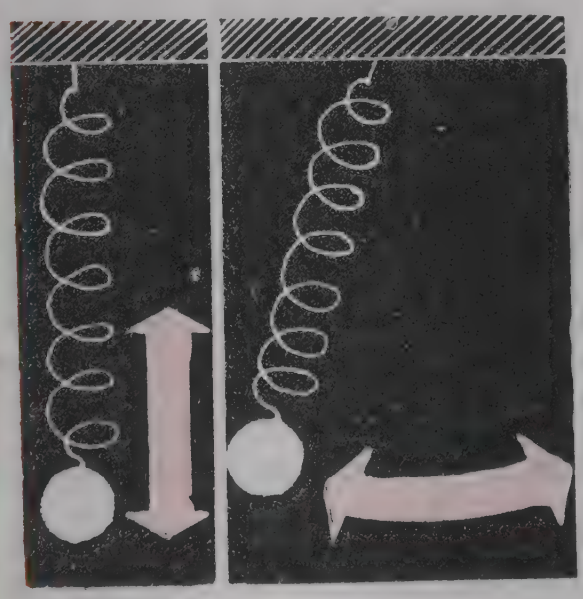
While stroking, let the forefinger press against the notched stick. The propeller will turn in one direction. Now, as you continue stroking, loosen the forefinger and press the thumb against the notched stick. What happens now? The propeller will turn in the *opposite direction*?

You can actually turn it into a magic show *by shifting from the forefinger to the thumb* (while everybody's eyes are focussed on the rotor) and making the rotor change direction alternately.

Let's tell you, while many have been able to figure out why the rotor turns at all (can you work it out?), many are still baffled by the mystery of why the *change of finger* should change its direction of spin.



• Spring pendulum

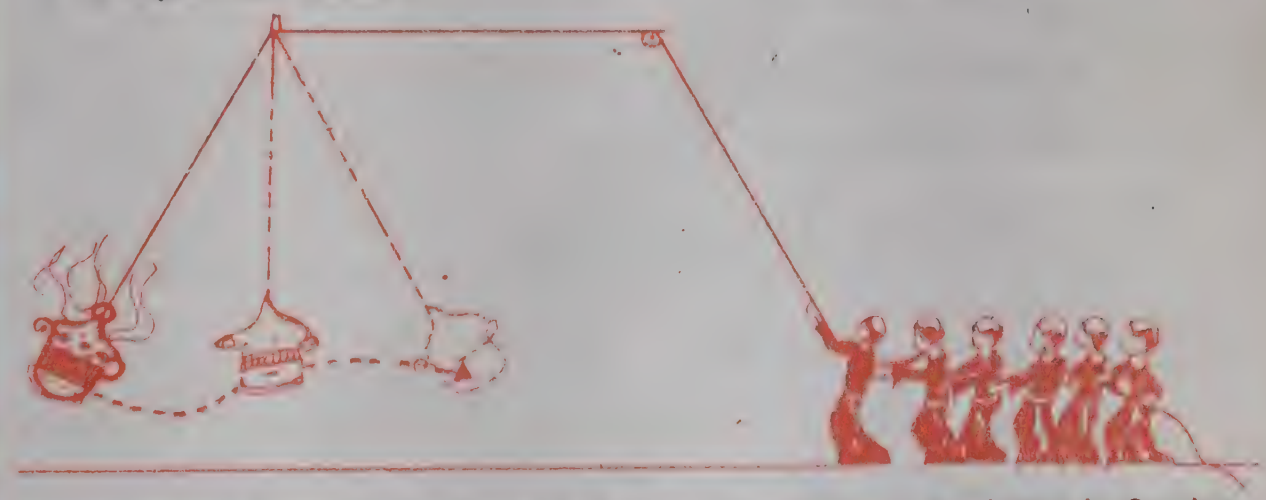


Did you know, if you choose the correct spring and bob, a vertically swinging spring pendulum will also swing *horizontally*? A vertical pull will start vertical oscillations in the pendulum, but as soon as the vertical motion comes to a stop, the bob will begin swinging *sideways*. Then, after the horizontal swing dies away, the *vertical* oscillation begins again. This will go on as long as there's energy left in the system.

Now, why does it happen?

[*Clue :* Coupled harmonic motion and sympathetic oscillation.]

• A Spanish puzzle



A famous place of pilgrimage in Spain is the shrine of St. James in Santiago de Campostella. Here, the faithful come to burn incense, in a large brazier hung from the ceiling of the church. To make the charcoal in the brazier burn well, the brazier is swung by the priests.

First, the brazier is swung with a small amplitude. Then, six men pull on a rope until the brazier swings through 180°.

Now, there's a curious element here: the six priests pull at the rope by *shortening* it by about a metre each time it passes through the vertical; when the brazier reaches its maximum height, they *release* a metre of the rope.

Can you work out why shortening and lengthening of the rope increases the amplitude of the swing?

[The three problems presented here are adapted from a remarkable compilation *The Flying Circus of Physics* by Jearl Walker.]

Mechanics and school physics

ECHANICS by S. R. Shankara arayana and K. L. Chopra, Sultan hand and Sons, New Delhi, 1976, s. 18

ECONDARY SCHOOL PHYSICS y N. K. Sehgal, K. L. Chopra and . L. Sehgal, Sultan Chand and ons, New Delhi, 1975, Rs. 3·50

Though the first book is titled *Mechanics*, principles of statics in general and their applications to the statics of structures, etc are not discussed. And nor are equilibrium of fluids and fluid motion. What are included, and treated carefully, are kinematics and dynamics of a particle, systems of particles and of rigid bodies. The reviewer sees no pedagogical reason why conservation laws of momentum, angular momentum and energy could not have been discussed in the earlier chapters. This would have avoided unnecessary duplication. A shorter chapter on the genesis of conservation laws through symmetry principles would then be in logical order. Similarly, the discussion of inertial systems of reference and the rotating frames of reference could go well together.

Surprisingly, though scattering is discussed, scattering cross-sections are not even mentioned. Their inclusion would have enhanced the value from the point of view of atomic and nuclear physics. However, a careful treatment of the scattering phenomena from a laboratory frame of reference has been given.

In the chapter on rigid body motion, I feel the motion of the symmetrical top would have brought out more significantly the importance of the use of Euler's equations rather than the two examples chosen.

The get-up is fairly good, except that bold face letters should have been used for vectors instead of those arrows and hats. In my opinion, the book is a very good and serious attempt.

Secondary School Physics is actually two text-books for Classes IX and X. It is written according to the (New) Secondary School Syllabus prescribed by the Central Board of Secondary Education, New Delhi. A good attempt is made to present the material in a fairly interesting manner by including many, though poorly drawn, pictures and diagrams.

Although sufficient care must have been taken by the authors to make the book free of mistakes, it contains, besides a few typographical errors, many erroneous statements. The very first sentence in " The fish's eye view " is wrong, while the related statement at the top of Fig. 12·9 is correct. On pages 66–67 (Class X), confusion about magnetic vectors H and B is made worse by statements like if the conductor (why conductor only?) is present in the medium, etc. The constant μ_o in the Coulomb's Law for poles appears in the wrong place due to the mistaken impression that μ_o corresponds to ε_o. In treating potential difference and EMF, no use is made of the energy concept; and why does the deflection of a gold-leaf electroscope indicate voltage (PD) rather than charge?

R. V. KAMATH

Hypnotism and hysteria

HYPNOTISM, HYSTERIA AND EPILEPSY — an historical synthesis by E. M. Thornton, William Heinemann, Medical Books Ltd, London, 1976, 205 pp, Rs. 95 (£5·95 net)

In an ambitious venture, the author has probed the historical leitmotif linking hypnotism, hysteria and epilepsy. Sir Wilder Penfield, celebrated neurosurgeon and author, earlier wrote several books on the historical aspects of epilepsy. This book follows the same tradition and provides an interesting insight into the origins of epilepsy. From the time Mesmer introduced hypnotism to clinicians and the lay public, medical enthusiasm for hypnotism has waxed and waned. Although hypnotism originated in France, it eventually fell into disrepute there. The study of hypnotism, which reached its zenith at the time of Charcot, was later almost completely abandoned as a scientific discipline. Readers, who are familiar with *The Story of San Michele* by Axel Munthe and with the vivid descriptions of Charcot's clinic, will understand the criticism and distaste for hypnotism that prevailed in some circles at that time. The author describes Prof. Bernheim's challenge to Charcot and his hypothesis that hypnotism is identical to natural sleep. In the light of current evidence on sleep mechanisms, his theories have proved fallacious.

More detailed information on animal experiments in hypnotism, together with an in-depth analysis of the role of hypnosis in therapy today, would have considerably increased the value of the book and served to link past history with the present-day medical scene. The book is anecdotal, well illustrated and has comprehensive author and subject indices. It is doubtful if the book will have a wide appeal for non-medical readers. And it is far too specialised to warrant purchase at the quoted price, except for large libraries.

JOY DAVID

[Dr. (Mrs.) David is with the CIBA-GEIGY Research Centre, Bombay.]

Computer languages

A SHORT INTRODUCTION TO THE ART OF PROGRAMMING by Edsgar W. Dijkstra, Computer Society of India, Bombay, 1977, 68 pp, Rs. 12 (paperback), Rs. 16 (hardcover)

Contrary to what the title might suggest, the book primarily addresses people who already know a computer language. It tells them how to ensure that the programs they write are correct from the very beginning. And, in the process, an aesthetically pleasing programming style is also developed.

While the primary readership is made up of computer programmers, the first two chapters use almost no technical terminology. The first explains such basic concepts as algorithm, program and machine, using instructions for a housewife to peel potatoes for dinner as the central example! The second one, on programming languages and their implementation, is a good introduction to the working of a computer, using little more than the notation of high school algebra. The next two chapters lay the foundation for the examples to follow. The building of proofs of programs is discussed and a number of theorems are established for the purpose. The need for proofs of correctness of computer programs is gaining wider acceptance among those in the trade. The proof techniques explained here are applicable to a wide range of programs.

The rest of the book is a succession of examples solved through stepwise refinement, also popularly known as structured programming. The examples do not represent everyday programming problems to most programmers.

The book is thought-provoking for practising computer programmers

(Contd. on p. 57)

Why does thunder end with a growl?

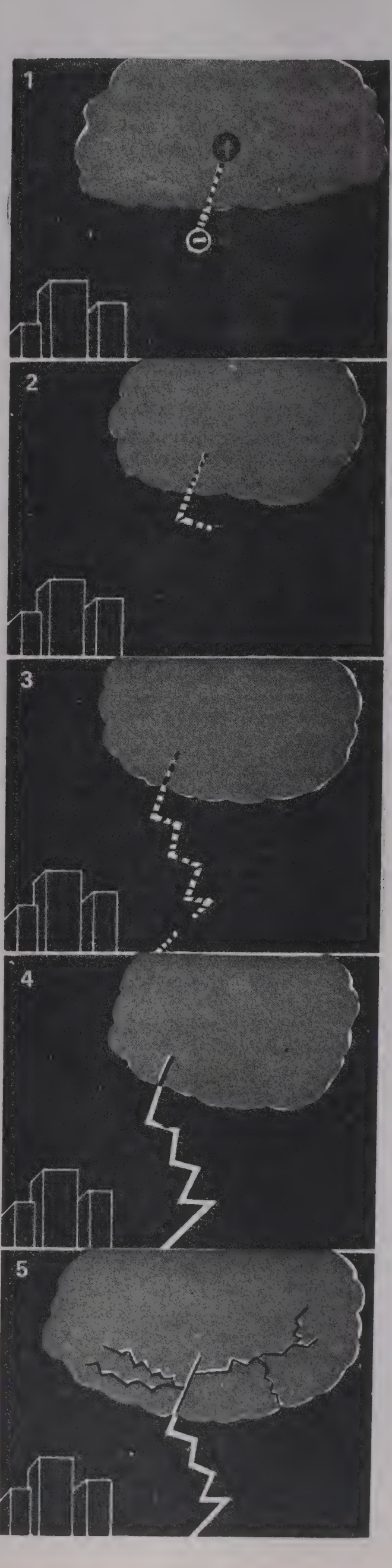
All of us are familiar with the relation between lightning and thunder. The initial flash of light is followed by the delayed burst of slower-moving sound. But notice how the thunder ends. Not with a bang, but a grumble—a slowly tapering, protracted growl. Why so?

Since the answer isn't in the textbook, after thinking about the question a little, our answer will most likely be that this effect is due to the many echoes of the initial burst as the sound bounces off nearby and distant hills, buildings and trees. By the same reasoning, a fisherman, caught out at sea during a storm, should hear only a sharp crack following the lightning stroke, without the protracted rumbles.

But fishermen and sailors do hear much the same sound of thunder as we do, complete with its rolling finale. So we move on to another conjecture, that each lightning bolt is followed by *smaller* strokes which give rise to corresponding acoustical after-effects. In that case, why don't we see those secondary flashes? Well, they could occur inside the dark cloud, invisible to an observer down on earth. According to this theory, then, invisible lightning strokes are postulated to explain the persistence of thunder. How valid is this explanation?

Let us examine the relation between lightning and thunder a little more closely. One would have thought that in this age of pinched plasmas and charmed quarks, the subject of lightning would, by now, be cut, dried, and tied. It remains, nonetheless, one of the least understood natural phenomena, with theories of lightning not having proceeded much beyond the descriptive stage albeit a fairly detailed and sophisticated description.

Measurements of the distribution of electric charge inside a rain cloud have shown that this distribution is highly non-uniform. The upper portions are positively charged, while the lower portions and the middle usually contain huge amounts of negative charge. Why and how this happens is one of the several problems which have remained unsolved. The release of the negative charge seems to be related to the process of condensation of water drops, which takes place at a sufficiently cool (that is, sufficiently high) altitude, usually at about five kilometres above the ground. Such large conglomerations of electric charge naturally give rise to strong electric fields between the bottom of the cloud and the earth, and within the cloud itself. For instance, just before a thunder storm, the potential difference between cloud and earth may reach as much as 300 million volts, which corresponds to an electric field of 600 volts per centimetre. Thus, there is a strong force on the electric charge sitting at the bottom of the cloud, impelling it towards the earth.



Now, a lightning bolt is a sequence of many events in which the cloud discharges some of its negative charge. It begins with a tentative probe known as a stepped leader. When the electric field in some region finally gets strong enough to overcome the insulation of the moist air, electrons begin to shoot down along the field lines. Along their path, they collide with various molecules, ionising them in the process, and, having thus dissipated their energy, they come to rest in a millionth of a second, 50 to 100 metres down the line. Then follows a relatively long pause of about 50-millionths of a second, after which a new step is formed from the leading tip of the first one. This sequence is repeated until the stepped leader reaches the ground, leaving in its trail a zig-zag of ionised air — a path of relatively low resistance, in other words, a jagged conducting ribbon connecting earth and sky. A burst of current now floods down this path carrying, perhaps, 10,000 amperes, and travelling with a speed of 10,000 kilometres per second. This is known as the first return stroke. As any resistive wire would in similar circumstances, the air along the conducting tube is rapidly heated to a high temperature. Molecules in the path are ionised, stripped, and excited to incandescence, producing the flash of light. Such rapid heating of a gas must be accompanied by its rapid expansion. A shock wave explodes outwards from the thin axis — the burst of thunder (Fig. 1).

Some tens of millionths of a second later, a second leader retraces the original path, sometimes opening forth new branches, and this leader, too, is subsequently followed by a second return stroke, usually of lesser intensity. Most lightning flashes consist of a number of such stepped leaders, each accompanied by its return stroke. Some have been photographed with as many as 30 return strokes. Here, no doubt, we have an explanation of our original

(Left) Fig. 1 Sequence of a lightning stroke — from stepped leaders to return stroke. Sequence 5 shows horizontal extension of a lightning bolt

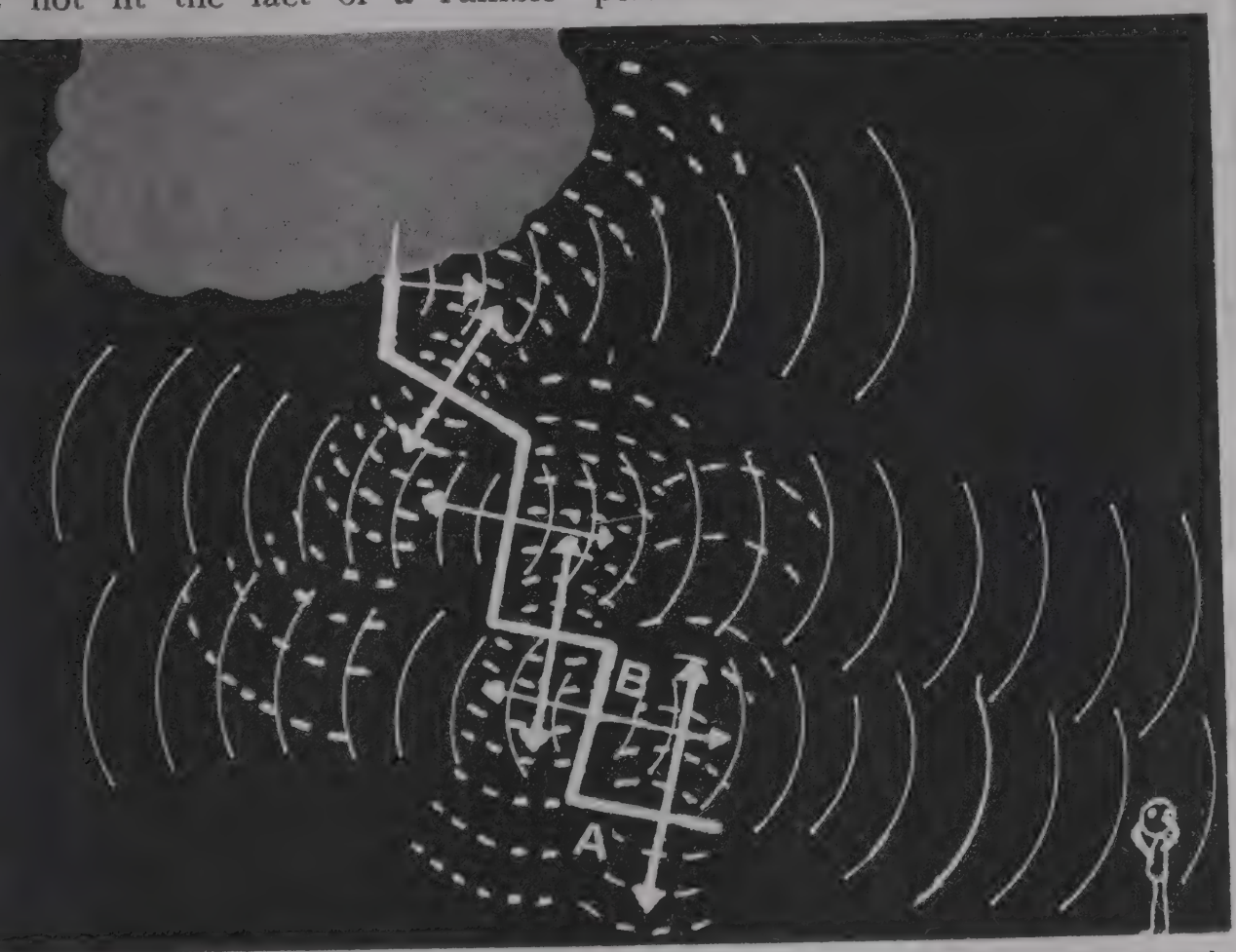
e. There is no need to invoke
n lightning. Each stroke must
esponsible for one boom of the
ble. This is indeed a plausible
nation, so let us proceed to
y it by calculating the total time
such a sequence, of, say, ten
es, will take. Assuming a length
ve kilometres for the path, each
er should take approximately one-
lredth of a second. Ten leaders
ld account for about one-tenth
second. Not very encouraging.
t about the main strokes?

ravelling at 10,000 kilometres per
nd, ten of these shouldn't take
nore than another few hundredths
second. The whole sequence of
its would be over in well under a
nd. So our newly found solution
not fit the fact of a rumble
sting 10 to 15 seconds. The pas-
ge of electrons down the crooked
d narrow path is much too rapid.
contrast, a sound wave would
ke some 15 seconds to travel down
e same length.

Now that the cat is out of the bag,
l that remains is to arrange for its
uick exit. Thunder, thus, is the
coustic output of an explosion which
kes place along a continuous length
some five kilometres. If the listener
placed so that the nearest point of
ne explosion is one kilometre from
im, the most distant point is still
ver five kilometres away. Even if the
xplosion is practically instantaneous,
s acoustical emission will last 12
15 seconds for the listener, as
ound from different spatial regions
f the explosion successively reach
is ear. According to this theory, the rumble should decrease in intensity from start to finish.

Observation proves otherwise. A later portion of the rumble is often louder than a preceding portion. Must we thus discard this explanation also?

It turns out that the emission of sound from each step of the exploding ribbon is strongly directional. Most of the sound output is sent out perpendicular to its length. Very little is emitted along its length (see Fig. 2). Now if we remember that the actual shape of the path is a three 1-dimensional zig-zag, it is easy to see that a nearby zig which is along the observer's line of sight, may emit less sound in his direction than a more distant zag which is oriented perpendicular to his line of sight. So the variation of loudness along the rumble also tells the observer the overall shape of the lightning stroke and how it is oriented with respect to him.



. 2 Sound output from each lightning step travels perpendicular to its length. ough step A is along the observer's line of sight, the sound from step B will be ard louder though it is farther away

By placing an array of microphones over an extended region, and monitoring the sound output of a lightning bolt, it is possible to infer with considerable accuracy its largescale structure. It is possible thus to 'look' at what is happening inside the dark cloud. It turns out that a lightning bolt often has a long horizontal portion extending within the cloud. This portion, which in a large cloud is of the order of 10 kilometres in length, is usually invisible. What we see then is less than half the story (though we hear all of it) or, if you wish, only the forked tongue of a luminous serpent.

VIVEK MONTEIRO

BOOKS *(Contd. from p. 55)*

and may improve their style. It can also prove useful as a joint textbook in introductory programming courses, together with a book or manual for the language used. At the very least, every teacher of programming must read it. Incidentally, Prof. Dijkstra's famous statement likening PL/1 — a programming language vigorously promoted by IBM — to a fatal disease appears on page 3 of this book.

H. V. SAHASRABUDHE

[Mr. Sahasrabudhe is Assistant Professor, Computer Centre, IIT, Kanpur.]

New maths

NEW MATHEMATICS (Book I to IV, 4 volumes) by C. V. Bhimashankaram and M. Imelda, Oriental Mudran, Bombay, 1976, Rs. 5·50 (Vol. I), Rs. 6·50 each (Vol. II to IV)

Much of the criticism of 'new math' is due to a lack of understanding on the part of the public and even some of the teachers. For successful adoption of a new mathematics programme, a school must ascertain where it would lead to and for what kind of students it was designed. The authors have made a sincere attempt to make this task easier at the elementary school level. Even untrained teachers and parents can follow the exposition of mathematical concepts.

Not much of the new mathematics in these books is really new. What is new is the emphasis on understanding the 'why' of mathematical operations and the attention given to mathematical structures.

A good strategy for teaching a mathematical concept must meet the demands of a proper teaching procedure and considerations of its applicability to the use of the concept later on. One of the first strategies the elementary school teacher must select is for the treatment of addition. Two different approaches are developed in the books. In the method on sets, addition is introduced by considering disjoint sets and their combination and by recording the number of objects in each. The treatment of this situation later on, using the symbolism and operations of sets, may be too much for many students, and is not at all essential at this level. On the other hand, the number line gives the relationship of numbers, the order, and is very useful in developing the properties of addition. It is also useful for the introduction of rational and real numbers and graphs at the secondary school level.

P. R. CHANDRASEKHAR

[Prof. Chandrasekhar teaches mathematics at Ramnarain Ruia College, Bombay.]

TWO-WIRE IC INTERCOM

The two-wire intercom set described below will be very useful in offices or in homes. The intercom set, when not in use, does not draw any current; thus, it can be economically supplied from a single 9-volt battery. The provision of call tone, from either set, is the unique feature. Secondly, it requires only two interconnecting wires between the two sets for the call tone as well as two-way communication. The use of a single integrated circuit CA 3020 makes the construction of the unit very simple. Two loudspeakers, one in each set, are used for two-way communication. Each one of them, in turn, is used as a microphone.

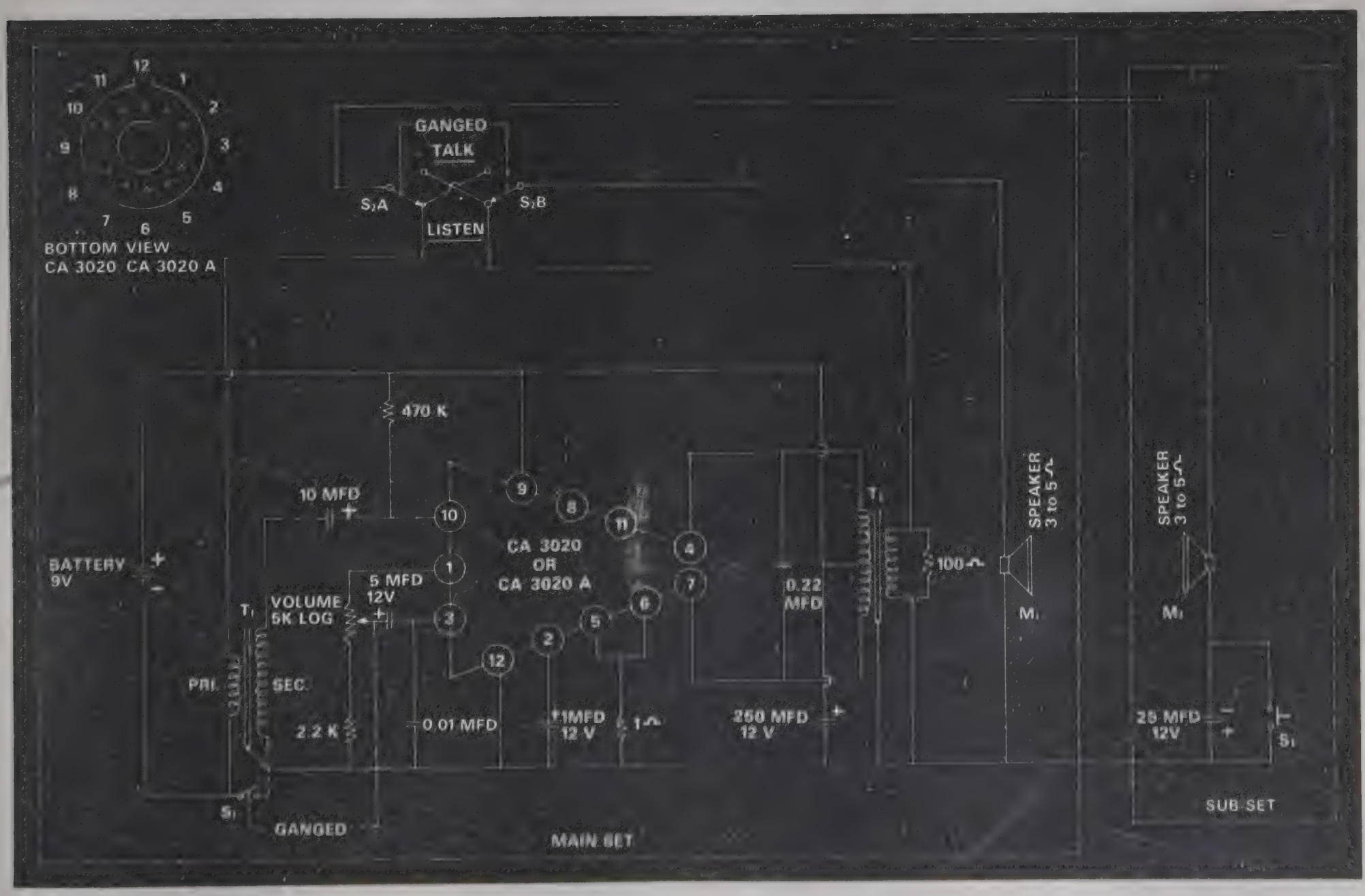
With the switch positions as shown in the diagram, the intercom set is "off". This is because the battery current cannot pass through the 25 mfd capacitor in the sub-set loudspeaker M2.

Call tone operation : If S2 alone is operated, then the battery gets connected to the IC amplifier circuit through the primary of the transformer T1 and loudspeaker M1. This initial current induces a corresponding emf across the secondary of transformer T1. As the voltage induced in the secondary supplies the input to the amplifier, and if the secondary is the right way round with respect to the primary, ie, in proper phase relation, then this input will make the amplifier draw more current through the battery. This will cause a regenerative action. When the increase in current of the amplifier, as the result of increase in input to the amplifier ceases, ie, when the amplifier saturates, the magnetic field around the primary collapses. This induces the voltage in the secondary again, but this time in the direction opposite to that previously induced. This retards the flow of current drawn by the amplifier till it reaches the bare minimum value. This current is much less than the 'normal' current drawn by the amplifier without any input. With the amplifier current at this minimum level, no voltage will be induced in the secondary of the transformer T1. There being no input, the amplifier will try to take its 'normal' current. This will, once again, induce the positive going input and the process will repeat. The whole action will occur at such a fast rate that each cycle will take a few milliseconds and what you will hear through the sub-set loudspeaker M2 will be audio oscillations as call tone.

Now, suppose S3 is closed, keeping S1 and S2 as shown in the diagram, then the battery current will pass through the primary of transformer T1 and loudspeaker M2 instead of loudspeaker M1. Similar oscillator action, as explained above, will take place and you will hear the call tone through the loudspeaker M1.

If the amplifier ceases to operate as an oscillator by operating either S2 or S3, then interchange the connections of either the primary or the secondary of the transformer T1, to give the feedback in the proper phase which will cause oscillations.

It is clear from the above explanation that when S2 alone is operated, the loudspeaker M2 gets connected at the output terminals of the amplifier and if S3 alone is operated, M1 gets connected at the output terminals. So



when S2, which is at the main set, is operated, it gives the call tone at the sub-set and when S3, which is at the sub-set, is operated, it gives the call tone at the main set.

Two-way Communication: When the call is attended to by the person at the other set, the switch S1 is to be switched on and S3 has to be switched off. This time the transformer T1 will act as a step-up component between the amplifier and the loudspeaker acting as the microphone. The listen-talk change-over can be operated by switch S2.

The output transformer T2 is readily available in the market. The transformer T1 is a special step-up transformer with primary to secondary turns ratio of about 1 : 30 or more. You can get this transformer made to order from any transformer manufacturer or you can wind it yourself with the details given below. If the size of the transformer T1 is not of much importance, then you can use the standard ready-made output transformer suitable for vacuum tube EL 84. While using this transformer, connect the normal low impedance secondary as primary, and vice versa.

Precautions: To avoid the interference of the mains supply, connect the laminations or brackets of both the transformers to ground, as shown in the diagram and, as far as possible, keep the wiring between the main and the sub-set units apart from the mains supply wiring. If required, you can use the standard 9V battery eliminator to replace the battery.

The main set and the sub-set, during testing, should be kept at least 3 metres apart to avoid the squealing sound caused by feedback through the air between the speakers.

Construction of transformer T1 :

Material required: 1. Enamelled copper wire; 43 SWG, 50 gm; 2. Core type: 17 CRGO grade 51, 100 gm; 3. Bakelite bobbin: Type 17 square $\frac{1}{2}$ in $\times$ $\frac{1}{2}$ in — 1 no.

Primary: 50 turns of 43 SWG enamelled copper wire.

Insulation: Interwinding (between primary and secondary) paper insulation.

Secondary: 1,500 to 2,500 turns of 43 SWG enamelled copper wire. Interlayer insulation not required.

You will need:

Integrated circuit: CA 3020 or CA 3020A, 1 no.

Capacitors: Electrolytic: 250 mfd 12 V, 1 no., 25 mfd 12 V, 1 no., 10 mfd 12 V, 1 no., 5 mfd 12 V, 1 no., 1 mfd 12 V, 1 no., polyester or ceramic: 0·22 mfd 1 no., 0·01 mfd 1 no.

Resistors (all $\frac{1}{2}$ watt): 470K Ω, 1 no.; 2·2K, 1 no.; 100 Ohms, 1 no., 1 Ohm, 1 no.

Volume control: 5K Ω logarithmic carbon with switch, 1 no.

Transformer: For T1: (see text for material and constructional details) or

Output transformer for EL 84, i e, Pri.: 5 K Ohms; Sec.: 3-5 Ohms, 1 no.

For T2: Push-pull output transformer 500 mW pri: 100-180 Ohms, sec: 3-5 Ohms, 1 no.

Loudspeaker: 500 mW type 3-5 Ohms, 2 nos.

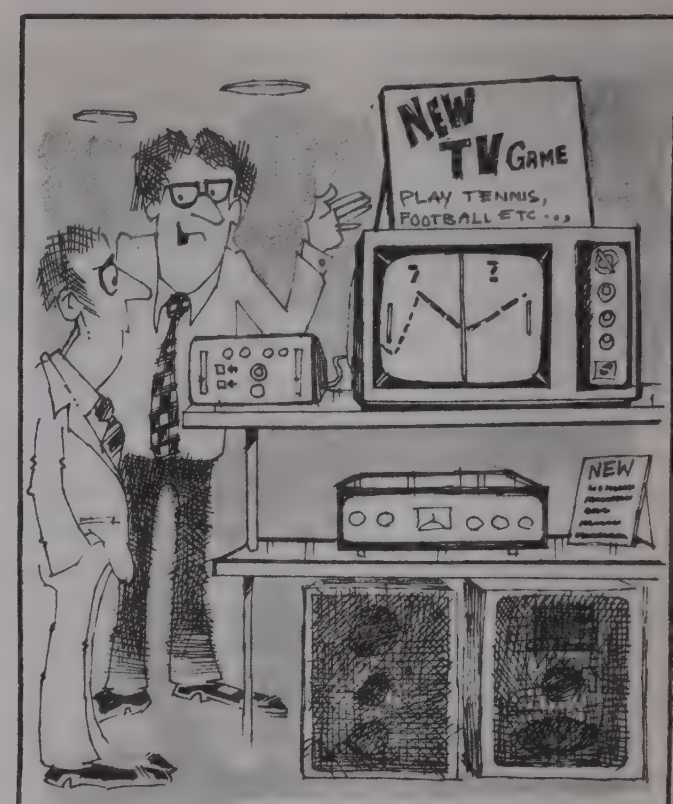
Switches: S1: Provided with volume control; S2: Two-pole, two-way (preferably self-resetting type) 1 no.; S3: normally open push button type.

Supply: 9 V battery 276-P type or 9 V battery eliminator, 1 no.

Misc: Screws, solder, wires, knobs, suitable enclosures, veroboard, etc.

The approximate cost of the components is Rs. 110.

ANIL V. BORKAR



"Buy two of these and you get a free recording of 'BOOS & CHEERS'!"

BRAIN TEASERS

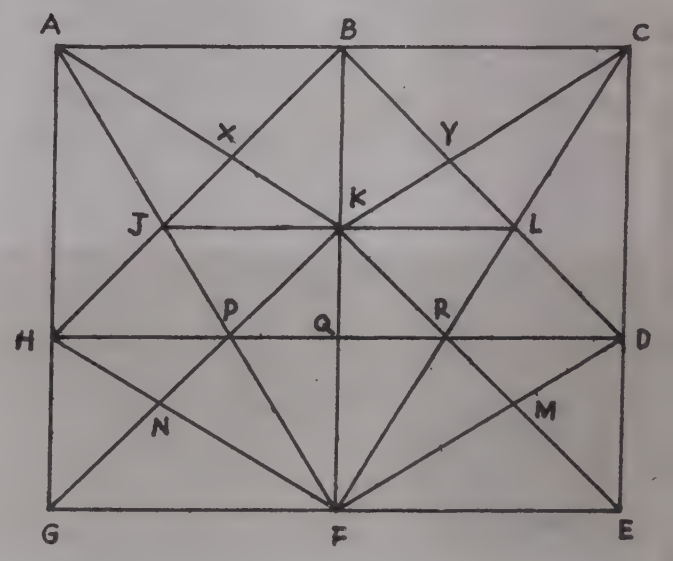
FAMILY AFFAIR : The principal of a college invited me to tea with the heads of the sections of his college. I learnt that they were a happy family (in more than a figurative sense) with five members; all but one held some important office in the college. Prof. Chatterjee is the principal's father-in-law and Prof. Doshi is his (principal's) brother-in-law. The vice-principal is going to marry the principal's cousin. Prof. Eshwaran's wife is the sister of the students' counsellor.

That day, apart from the principal, I met the hostel warden, Prof. Eshwaran and Prof. Doshi. The following week, I met three of them in a cinema theatre. One of them, Prof. Banerjee, I met for the first time. The others were Prof. Acharya and Prof. Doshi. What office, if any, does each of them hold ?

V. A SHENAI

MANY-IN-ONE: How many triangles are there in the figure below?

SHAIK MAHMOOD



(Solutions next month)

Answers to last month's Brain Teasers

How many students ?

The last two digits in the product indicate that the numbers of students have 3 and 7 as their last digits. Let X and Y be their first digits, so that $10X + 3$ and $10Y + 7$ are the required numbers.

Now $(10X + 3)(10Y + 7) = 2021$

ie, $100XY + 30Y + 70X + 21 = 2021$

ie, $10XY + 3Y + 7X = 200$

Let $X - Y = K$

substituting $X = K + Y$,

$10(K + Y)Y + 3Y + 7(K + Y) = 200$

Rearranging,

$10Y^2 + (10K + 10)Y + (7K - 200) = 0$

This is a quadratic equation in Y and its positive root is given by

$$Y = \frac{-(10K+10)+\sqrt{10^2(K+1)^2-40(7K-200)}}{20}$$

$$= \frac{-(K+1)+\sqrt{(K+1)^2-2.8K+80}}{2}$$

$$= \frac{-(K+1)+\sqrt{K^2+2K+1-2.8K+80}}{2}$$

In this case Y will be rational only if $K = 0$. In that case,

$$Y = \frac{-1+\sqrt{81}}{2} = 4.$$

So X is also 4

The required numbers are 43 and 47.

Oversight

Suppose M is the price of each mathematics book and C of each chemistry book, and Nm and Nc are the numbers of mathematics and chemistry books bought.

$NmM + NcC = 1150$

Then, $NmC + NcM - NmM - NcC = 100$

$(Nm - Nc)(C - M) = 100$.

Now, $C - M = Nm - NC$. Therefore, each must be equal to 10.

ie, $Nm - Nc = 10$

But $Nm + Nc = 60$

Hence, $Nm = 35$ and $Nc = 25$.

$C - M = 10$

$C = M + 10$

Also, $35M + 25(M + 10) = 1150$

So $M = 15$ and $C = 25$

TELL US WHY...

. . . animals' eyes shine in the dark?

If you prefer to be a stickler, you could say, they don't! In complete darkness, animals' eyes don't shine; they don't give off a light on their own. Technically, the question ought to be rephrased like this: Why do animals' eyes reflect light directed into them? Walk into the woods at night and flash a torch and you can see several such shining eyes: little pricks and glitters of topaz to let us know that there is a spider hiding in this shrubbery, glints of green witchfire to betray the presence of a stealthy fox behind that fallen log, a quick blaze of glowing red which could mean your torch beam has discovered a rabbit. Why doesn't it happen with human eyes?

The reason is, animals are largely nocturnal; the dark hours are when they do most of their hunting and prowling. Behind the retinas of these night explorers' eyes, instead of a dark layer of pigment, they have what amount to mirrors. The faint light in which they have to do their seeing — moonlight, starlight — is reflected by these mirrors and thereby multiplied. Nocturnal animals' eyes shine for the same reason that roadside reflector buttons shine.

Can cats see in total darkness? No, but they can utilise a minimum amount of light much better than humans can. With such sensitive vision in very dim light, then, why aren't they blinded in brilliant sunshine? Because they have slit pupils. They can narrow the slits, at noontime, until less daylight enters than through a pinhole.

While we are on this matter of animals' vision, let's consider several other questions that crop up frequently.

Is it true that a rabbit can see what is going on behind its back? Empty-handed hunters have often sworn this must be the case; and as a matter of fact, it is. Rabbits' eyes have such a protruding convexity that they can contemplate virtually a full circle.

Why are bulls said to be particularly excited by the red colour? They aren't. Bulls are colour-blind. Repeated experiments by a number of investigators of animal life have made it certain that bulls inhabit a visual world of only black and white and intermediate grays.

How about other animals? Are they all colour-blind? We cannot say with absolute certainty, of course, but among all the animals that have been studied in this respect, colour blindness has been found general with only two exceptions: monkeys and apes.

. . . why are some birds' eggs plain-coloured while others are speckled?

We'd have to read nearly a bookful of evolutionary oölogy to explore this fully, but putting it in the briefest and simplest way, it goes like this. Originally, we can take it, birds' eggs were all just yellowy-white like the eggs of their reptile forebears. With birds' development of the nesting habit as a protective device, the colouring of their eggs also became protectively adapted.

Take birds that nest in holes and dark, protected crannies of one sort or another — birds like kingfishers and woodpeckers. They lay white eggs. After all, their eggs are invisible by virtue of the nest environment. But take the eggs of killdeer plovers which are laid on the ground. They are streaked and mottled in such semblance of pebbly soil that they are almost invisible even when we are staring straight at them.

But then, what about solid blue and solid green and variously blotched eggs that we find among the birds that nest neither on the ground nor in holes but on trees? These, as the evolutionists put it, are probably degenerations, meaning that, whereas the pigmenting of eggs presumably started in the first place as a protection when all birds' eggs were laid on the ground, the pigmenting is now in the process of dying away among those birds that have taken to nesting in places where the eggs don't need it. If we do some nest exploring, we can soon find out that the eggs of a great many birds vary a lot in their colouring and markings. Phoebes' eggs are sometimes quite heavily speckled, and sometimes have no speckles at all. Sparrows' eggshell colours vary immensely, all the way from nearly white to such dense spotting as to be almost solid brown.

SUDHIR D. GHATNEKAR

[Dr. Ghatnekar is on the staff of the Biology Department of Ramnarain Ruia College, Bombay.]

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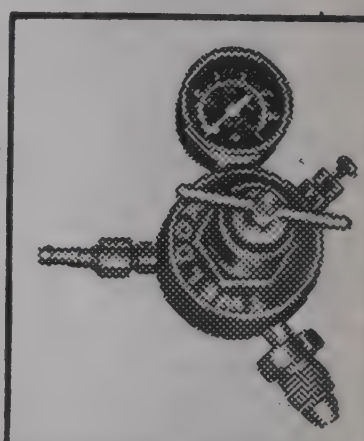

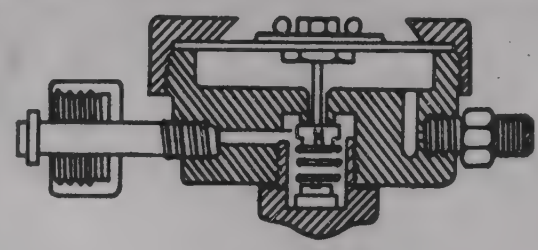

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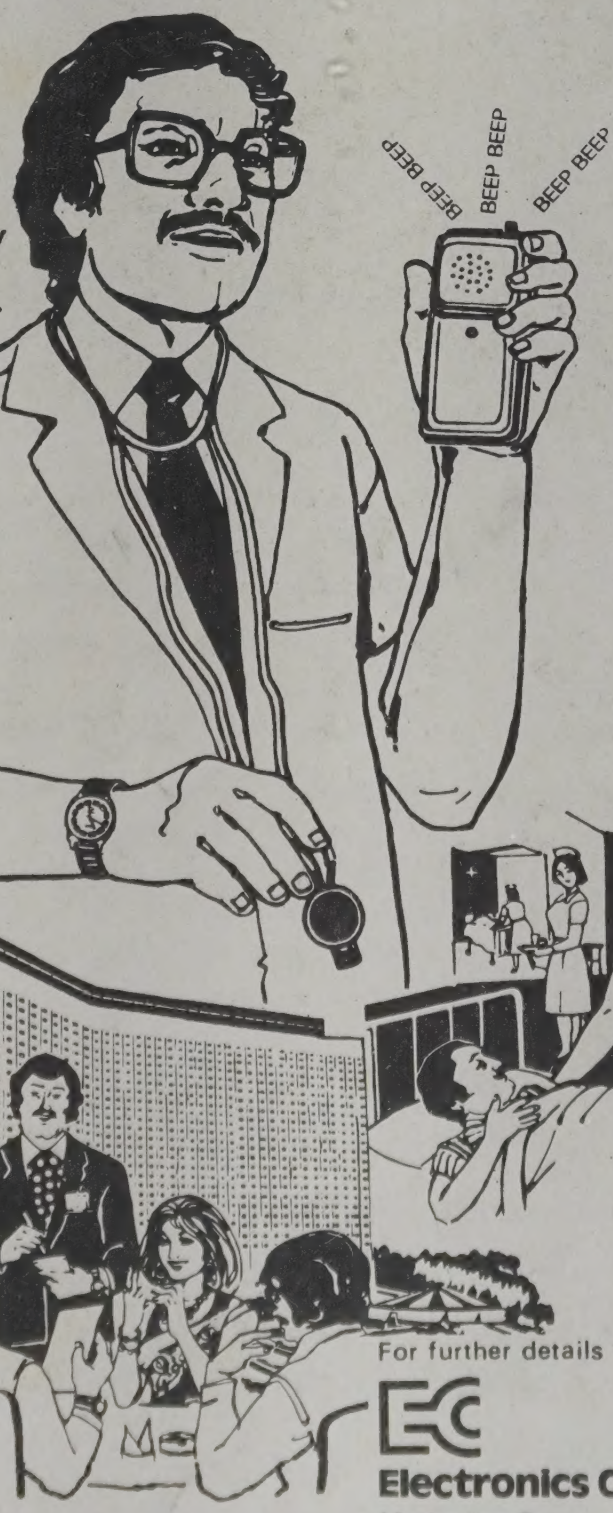

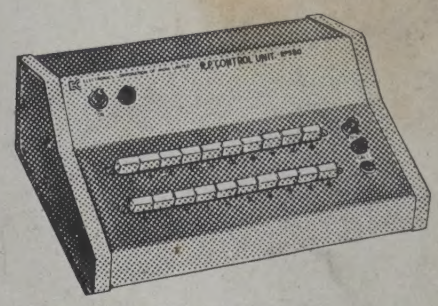

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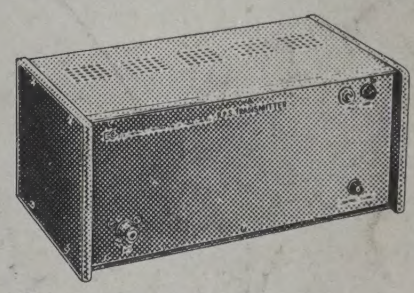

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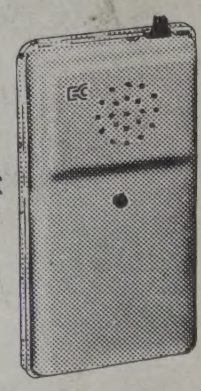

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